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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

PHYSICS-BASED MODELING AND ASSESSMENT OF MOBILE LANDING PLATFORM SYSTEM DESIGN

by

Christopher G. Williams

September 2008

Thesis Advisor:	Fotis Papoulias
Co-Advisor:	Joshua Gordis

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13. ABSTRACT (maximum 200 words)

In this thesis, the overall throughput rate is examined from a container ship servicing the Sea Base to the objective ashore with attention paid to the Mobile Landing Platform. An initial study was conducted using a variety of air and surface connectors considering the various technologies being developed for the Sea Base concept and the use of a T-AKE class ship acting as a warehouse. A second study was then conducted taking the results from the initial sturdy to determine the maximum number of surface connectors could be employed to maximize the logistical throughput without incurring a wait time. The number of loading spots versus the amount of deck space available for stowage of cargo was calculated for the various cases. The surface connectors considered were the Landing Craft Air Cushioned (LCAC), the Next Generation Landing Craft Air Cushioned (LCAC(X)) and the Sea Base Connector Transformable Craft (T-Craft). Finally, a separate logistics simulation developed by Professor Gordis was then used to compare the different connectors, the effect of increasing the available deck space on the Mobile Landing Platform and the effects of technologies which would increase the connector load times.

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PHYSICS-BASED MODELING AND ASSESSMENT OF MOBILE LANDING PLATFORM SYSTEM DESIGN

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Submitted in partial fulfillment of the
requirements for the degree of

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from the

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September 2008

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In this thesis the overall throughput rate is examined from a container ship servicing the Sea Base to the objective ashore with attention paid to the Mobile Landing Platform. An initial study was conducted using a variety of air and surface connectors considering the various technologies being developed for the Sea Base concept and the use of a T-AKE class ship acting as a warehouse. A second study was then conducted taking the results from the initial sturdy to determine the maximum number of surface connectors could be employed to maximize the logistical throughput without incurring a wait time. The number of loading spots versus the amount of deck space available for stowage of cargo was calculated for the various cases. The surface connectors considered were the Landing Craft Air Cushioned (LCAC), the Next Generation Landing Craft Air Cushioned (LCAC(X)) and the Sea Base Connector Transformable Craft (T-Craft). Finally, a separate logistics simulation developed by Professor Gordis was then used to compare the different connectors, the effect of increasing the available deck space on the Mobile Landing Platform and the effects of technologies which would increase the connector load times.

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A special thank you goes to my wife Elizabeth for her support and assistance in writing this thesis. Also, thank you to my daughter Ella and my son Thomas who always helped my keep a light heart. My sincere thanks go to my thesis advisor, Professor Fotis Papoulias for his guidance in this project and his assistance in working around my professional obligations. Also, thank you to my co-advisor, Professor Joshua Gordis for his help with the MATLAB Simulation. Without which this project would have had much less value. These people's collective support, direction, and assistance are what made this project possible.

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I. INTRODUCTION

Current Chief of Naval Operations, Admiral Gary Roughead, as well as his two predecessors has each stated that the future of amphibious operations lays in the Sea Basing concept [1], [2], [3]. Ideally, this will include air and/or surface connectors operating from a Mobile Landing Platform (MLP) as shown in Figure 1. In the winter of 2008, Geoff Main, a representative of the Office of Naval Research (ONR) approached the Naval Postgraduate School (NPS) to conduct an overall study of Sea Base enabling technologies. This thesis's purpose is to take the Sea Base technologies being developed by the Office of Naval Research and conduct an initial system design of the Mobile Landing Platform. The study is broken into three sections: the Initial Study, the Mobile Landing Platform Model, and the Throughput Simulation which are described below.

A. INITIAL STUDY

The initial study uncovers trends and discovers weak links in the Sea Base supply chain from cargo container ship to the objective ashore via the MLP. The various technologies being developed by ONR are examined in the initial study and considered for MLP Model and the Throughput Simulation. Several of these technologies are critical enablers such as the Large Vessel Interface Lift On / Lift Off, meaning that the operation cannot proceed without them. Others, such as Automated Warehouse, may or may not increase overall throughput. Microsoft Excel was used to provide a visual representation of multiple situations (i.e., different technologies, number and types of connectors) so that recommendations could be made on the Sea Base architecture.

B. MOBILE LANDING PLATFORM (MLP) MODELING

Second, the study takes trends discovered in the initial study and refines the Sea Base architecture. This architecture is then used to develop a program which models the MLP to determine the maximum amount of surface connectors that may be utilized without saturating the logistical train, thereby causing inefficiencies in the system. Also, the model will consider how many loading spots as well as how much storage space must

be on the MLP given a certain number and type of surface connector. The number of connectors, loading spots, and storage space will finally be given as a function of the connector load rate. Demonstrations have shown that this part of the logistical train may be done with Landing Craft-Air Cushioned (LCACs) "flying" onto one of the modified commercial heavy lift ships such as MIGHTY SERVANT 1. Since the surface connectors will dominate the logistical throughput; the study will concentrate on this area with the air connectors being examined in the initial study only.

C. THROUGHPUT SIMULATION

The third and final section takes the number of surface connectors evaluated, the number of loading spots, and the amount of storage space on the MLP and inputs them into a throughput simulation. This simulation, developed by Professor Joshua Gordis, Naval Postgraduate School, then compares the different types of connectors being considered, and discovers advantages that may be gained in the throughput with investments in several technologies.

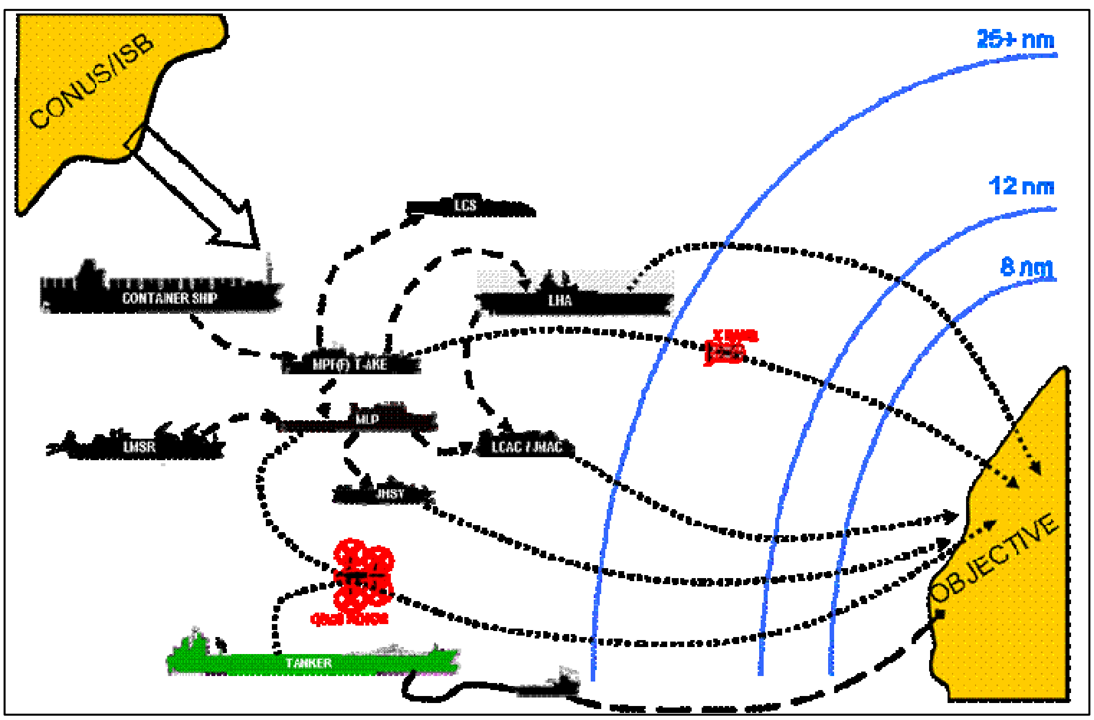

Figure 1. Sea Base Scenario

Upon conclusion, this study will take the results of the Initial Study, the MLP Model, and the Throughput Simulation and will offer a recommendation on the concept design of the MLP in order to maximize the logistical throughput and provide additional recommendations for areas of further research.

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II. SEA BASE OVERVIEW

A. SEA POWER 21

Sea basing is defined as “enhanced operational independence and support for joint forces provided by networked, mobile, and secure sovereign platforms operating in the maritime domain” [2]. Admiral Clark, former Chief of Naval Operations stated in Sea Power 21 in 2002, “We often cite asymmetric challenges when referring to enemy threats, virtually assuming such advantages belong only to our adversaries. "Sea Power 21" is built on a foundation of American asymmetric strengths that are powerful and uniquely ours” [2]. The goal of the Sea Base is to provide the Combatant and JTF Commanders with an integrated command and control and logistic support capability joint in nature. By keeping these capabilities afloat, Sea Basing strengthens force protection and frees strategic airlift and sealift to support missions ashore. The Sea Base consists of numerous platforms to include aircraft carriers, amphibious ships, surface combatants, and the strategic sealift fleet. Sea Basing as defined in Sea Power 21 also provides the following [2]:

1. Sea Basing Impact

- Pre-positioned warfighting capabilities for immediate employment
- Enhanced joint support from a fully netted, dispersed naval force
- Strengthened international coalition building
- Increased joint force security and operational agility
- Minimized operational reliance on shore infrastructure

2. Sea Basing Capabilities

- Enhanced afloat positioning of joint assets
- Offensive and defensive power projection
- Command and control

- Integrated joint logistics
- Accelerated deployment and employment timelines

3. Future Sea Basing Technologies

- Enhanced sea-based joint command and control
- Heavy equipment transfer capabilities
- Intra-theater high-speed sealift
- Improved vertical delivery methods
- Integrated joint logistics
- Rotational crewing infrastructure
- International data-sharing networks

4. Sea Basing Action Steps

- Exploit the advantages of sea-based forces wherever possible
- Develop technologies to enhance on-station time and minimize maintenance requirements
- Experiment with innovative employment concepts and platforms
- Challenge every assumption that results in shore basing of Navy capabilities

B. CURRENT STATE – SEA POWER FOR A NEW ERA (2007)

1. Importance of Sealift

The importance of sealift cannot be over stated. It allows for the movement and support for U.S. combat forces afloat and ashore. In combat operations in the Arabian Gulf from Desert Shield/Desert Storm in 1990 to Operation Iraqi Freedom in 2003, sealift transported ninety five percent of all supplies to and from the areas of operations [3]. Sea Basing will expand upon this already robust capability.

2. Strategic Sealift Fleet

The Navy’s strategic sealift fleet is broken down into three areas:

- The Prepositioned Force
- The Surge Fleet
- Other support ships.

The first area is the Prepositioned ships which include the Maritime Prepostioning Force which supports the Marine Corps, the Combat Prepostioning Force which supports the Army, and the Logistics Prepositioning Ships which support the Navy, Air Force, and Defense Logistics Agency. The Surge Fleet consists of Fast Sealift Ships (FSS), Large Medium-Speed Roll-On Roll-Off (LMSR) ships, and the ships of the Maritime Administration’s Ready Reserve Force (RRF). The final assets include hospital ships, aviation maintenance ships and commercial sealift assets if contracted to support specific mission requirements [3].

3. Future of Sea Basing

Even now, Sea Basing platforms are supporting emerging concepts of Operational and Ship-to-Objective Maneuver which are hallmarks of expeditionary maneuver warfare [3]. These concepts, combined with new doctrine and emerging technologies will enable the military to achieve its goal of allowing joint and allied forces the capability to deploy and sustain operations without dependence on shore based infrastructure in forward and sometimes remote areas.

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III. ENABLING TECHNOLOGIES

Several new technologies being developed through the Office of Naval Research will be considered in this study. These technologies are aimed at addressing the onload, offload, and material management aspects of the Sea Basing concept. Their goal is to improve the receipt, handling, stowage, and offload of stores to forces ashore [4]. Technologies being considered are:

- Large to Large Vessel Interface Lift On/Lift Off (LVI LO/LO)
- Shipboard ISO Container Breakout and Repacking (CB&R)
- Compact Agile Material Mover (CAMM)
- Automated Warehouse (AW)
- High Rate Vertical/Horizontal Movement (HRVHMM)
- Interface Ramp Technologies (IRT)
- Small to Large Vessel At-Sea Transfer (STLVAST)

These technologies will be explained below and future capability surface and air connectors such as the Sea Base Connector Transformable Craft (T-Craft) and X-Craft will be discussed in Chapter IV.

A. LARGE TO LARGE VESSEL INTERFACE LIFT ON/LIFT OFF (LVI LO/LO)

Figure 2. Large to Large Vessel Interface Lift On/Lift Off From [5]

Large to Large Vessel Interface Lift On/Lift Off (LVI LO/LO) is one of the most essential technologies to the Sea Base concept. This technology enables the transfer of standard ISO containers and other heavy loads from a variety of military and commercial ships. Without it, the T-AKE would have to return to an advance base to resupply every few days depending upon the size of the force ashore. This could double or even triple the number of ships required to fulfill the Sea Base mission. Details of this proposed capability include: motion sensing and compensation for the ships and/or the cranes which will allow safe and efficient transfer of cargo, ability to maintain optimal cargo throughput rates through sea state four, and the ability to transfer cargo between two ships directly alongside each other at zero forward speed or underway at slow speed in the open ocean [4]. The metrics for the LVI LO/LO are 20 lifts per hour for standard ISO containers, operational through sea state four with an objective of sea state five, and an interface/disconnect for operational connectivity of the Sea Base platforms established at a threshold of two hours with an objective of one hour [4].

B. SHIPBOARD ISO CONTAINER BREAKOUT AND REPACKING (CB&R)

The Shipboard ISO Container Breakout and Repacking (CB&R) technology is being developed to efficiently breakout the pallets from the containers delivered from a cargo container ship. A standard ISO 20 ft container will be unloaded at an objective of five minutes (objective) and ten minutes (threshold) using a minimal amount of operators and machinery. The container will then be repacked with retrograde at an objective of 10 minutes (objective) and 15 minutes (threshold). All of this will be accomplished while maintaining positive control through sea state five [6].

C. COMPACT AGILE MATERIAL MOVER (CAMM)

The overall purpose of the CAMM technology is to increase the internal movement of cargo onboard ships by a highly maneuverable, omni-directional material mover enabled by human strength amplification technology, omni directional movement capability along with ship motion compensation algorithms. This program was canceled, however, in FY07 due to the loss of a transition sponsor [4]. The capability is included in the model to study the need for a technology such as this without regard to its specifics. With this, a metric of 70 tons per hour for the T-AKE strike up and strike down rates is used for the initial study.

D. AUTOMATED WAREHOUSE (AW)

Automated Warehouse (AW) is another capability that is focused on throughput internal to the T-AKE. It takes existing commercial Automated Storage and Retrieval Systems (ASRS) and adapts them to shipboard environments for the purpose of not only dramatically increasing throughput, but also reducing workload and increasing reliability in material handling tasks by replacing time consuming manual tasks by an automated stowage and handling system [4]. (See Figure 3)

Figure 3. Automated Warehouse From [7]

This technology has recently transitioned to the research and development phase in FY07 and in this model, the enabling capability metric of 105 tons per hour throughput rate is used [4].

E. HIGH RATE VERTICAL/HORIZONTAL MATERIAL MOVEMENT (HRVHMM)

The High Rate Vertical/Horizontal Material Movement (HRVHMM) is a system designed to be interoperable with the Automated Warehouse. This capability is designed to provide an end to end solution for internal cargo movement to include a seamless transition from horizontal modes to vertical modes. It will ultimately replace the current system of elevators, conveyors, dumb waiters, chain falls and other handling equipment [4].

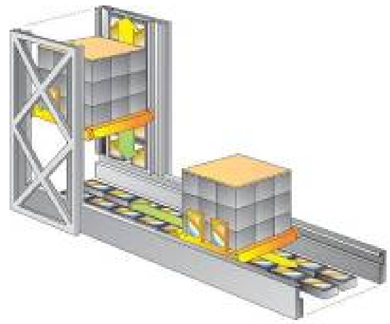

Figure 4. High Rate Vertical/Horizontal Material Movement (HRVHMM) From [7]

Ideally, this system will take cargo from storage directly to the transfer station (i.e., flight deck for the air connectors or the ramp for transfer to the MLP) without any requirement for additional handling. For the model, a throughput rate of 105 LT per hour with a threshold of 70 LT per hour is used [4].

F. INTERFACE RAMP TECHNOLOGIES (IRT)

The capability of transferring cargo between the T-AKE and the MLP is enabled by Interface Ramp Technologies. The transfer of material at a high rate between two large vessels without moving through the water is a complicated problem. The essential function can be seen in Figure 6. The installation of this ramp on the T-AKE would of course require a major modification to current T-AKEs. The initial study intends to discover if this would be a worthwhile investment.

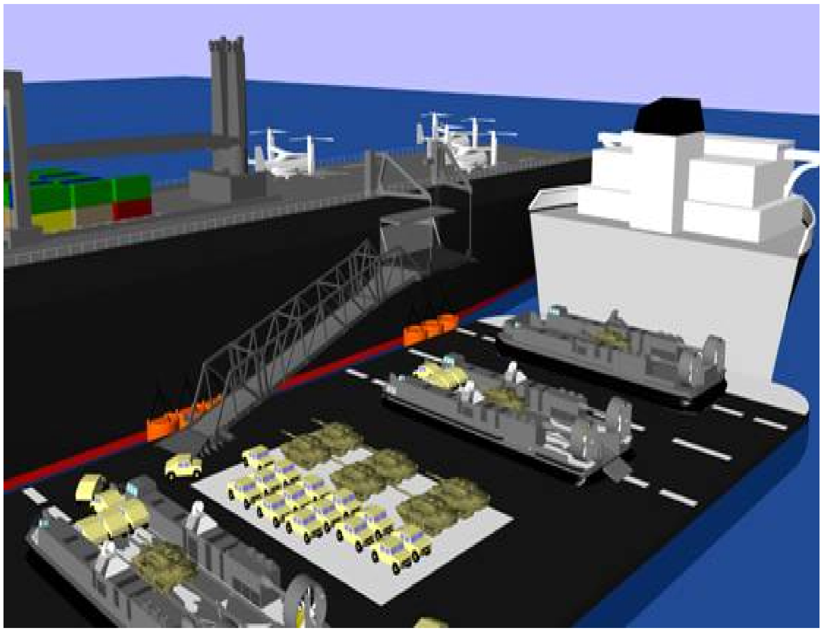

Figure 5. Interface Ramp Technologies From [7]

G. SMALL TO LARGE VESSEL AT-SEA TRANSFER (STLVAST)

The Small to Large Vessel At-Sea Transfer (STLVAST) capability enables the transfer of cargo from the MLP to smaller surface connectors. Potential products may include collapsible wing walls combined with low freeboard to guide the connectors onto the deck and stabilize once in a loading position. Also, fendering will be used to accommodate other vessels such as the Joint High Speed Vessel (JHSV). The use of LCACs as connectors has been experimented in actual LCAC operations with the Dockwise ship, MIGHTY SERVANT 1, to be discussed in the vessels section.

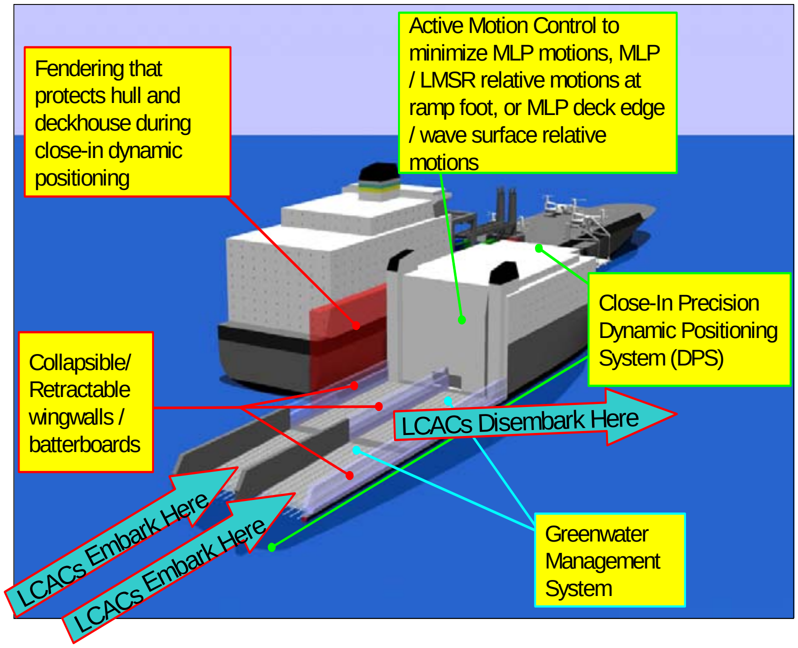

Figure 6. Theoretical Small to Large Vessel At-Sea Transfer (STLVAST) From [7]

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IV. PLATFORMS

A. LOGISTIC VESSELS

1. Cargo Ship

The cargo ship used for this model is a typical cargo ship with the following characteristics shown in Table 1.

Speed	25 kts
Capacity	5260 TEU (Twenty Foot Equivalent Unit) Containers [8]
	126000 tons cargo

Table 1. Cargo Ship Characteristics

The cargo carrying capacity was taken as the average of one of the major ship lines, in this case Maersk Line. Each container contains approximately 24 tons of cargo and the speed was also taken as a nominal container ship speed.

Figure 7. Container Ship From [9]

2. T-AKE

The Lewis and Clark Class (T-AKE) Dry Cargo/Ammunition Ship is used in the model as the Sea Base warehouse taking stores from the Cargo Ship and delivering the stores to the Mobile Landing Platform (MLP) as seen in Figure 8.

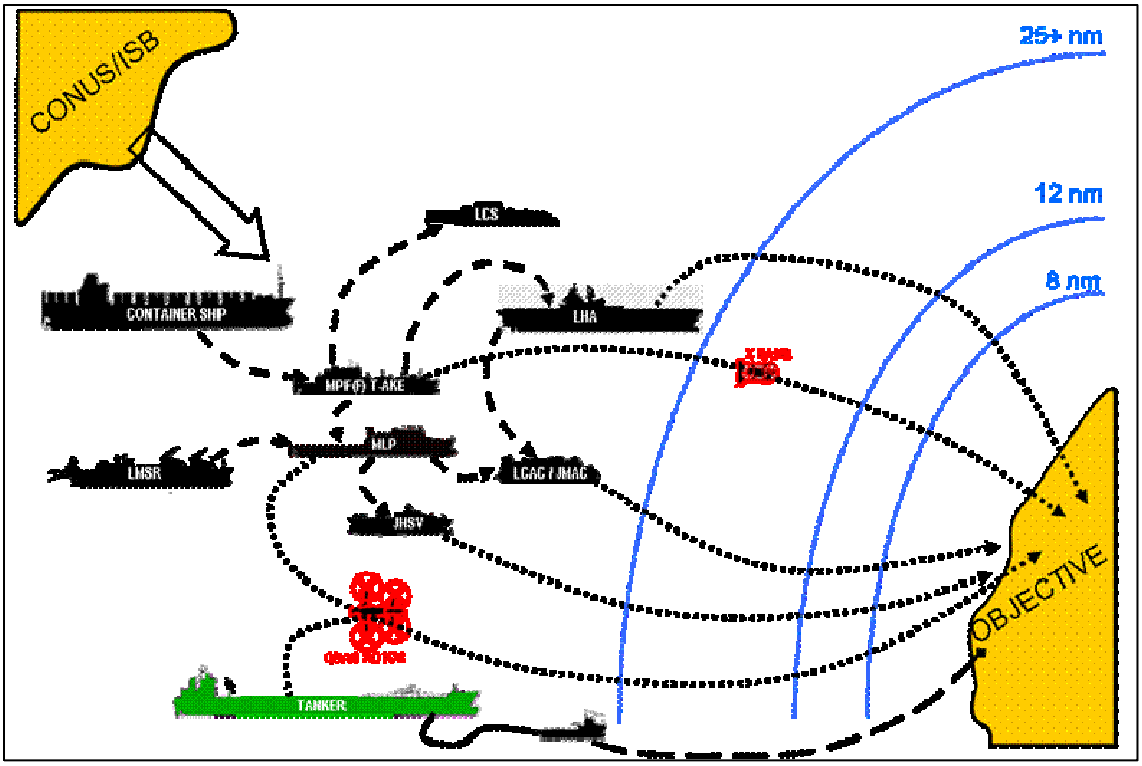

Figure 8. Sea Base Scenario

Currently being built by National Steel and Shipbuilding Company in San Diego, CA, this class represents the next generation of logistic ships. Its stated mission is to "deliver ammunition, provisions, stores, spare parts, potable water and petroleum products to carrier battle groups and other naval forces, serving as a shuttle ship or station ship" [10]. The characteristics are listed below.

Length (Overall)	689 ft
Beam	105.6 ft
Draft (Design)	29.9 ft
Displacement	40352 LT
Speed	20 kts
Range	14000 nm
Dry Cargo Capacity	7358 tons
Cargo Fuel Capacity	23,450 bbl
Cargo Potable Water Capacity	52,800 gal

Table 2. T-AKE Characteristics From [10]

The design of this class of ships makes it ideal to act as the hub in the Sea Base architecture. Here the Large to Large Vessel Interface Lift On/Lift Off and the Interface Ramp Technology are critical to the transfer of cargo between the container ship and the mobile landing platform respectively. Also, the effect of the Compact Agile Material Mover, Automated Warehouse, and High Rate Vertical/Horizontal Material Movement technologies is observed versus traditional strike up and strike down methods on the T-AKE to see if these new technologies make a worthwhile investment.

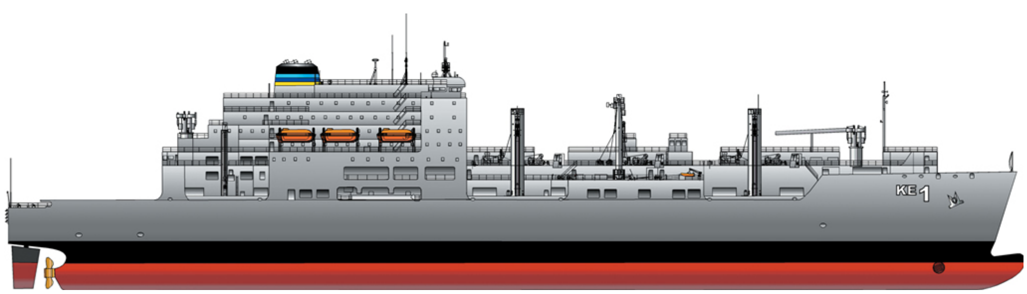

Figure 9. Lewis and Clark (T-AKE 1) Dry Cargo/Ammunition Ship From [11]

3. Mobile Landing Platform

MIGHTY SERVANT 1 is used as the Mobile Landing Platform (MLP) for our model. Here, the results of the concept demonstration conducted in 2005 by Naval Surface Warfare Center (NSWC) Carderock Division are closely followed. A need was

identified early in the Sea Base concept for an interface between the Sea Base ship, in this case the T-AKE, and surface connectors such as Landing Craft – Air Cushioned (LCAC) [12]. A commercial heavy lift ship was envisioned due to it's large deck which could be ballasted down to enable LCACs to "fly" on while at the same time accepting a ramp from the Sea Base ship. Interface Ramp Technology (IRT) is essential for the transfer of goods to the MLP and the Small to Large Vessel At-Sea Transfer Sea Base Connector (STLVAST) is essential for the loading of surface connectors.

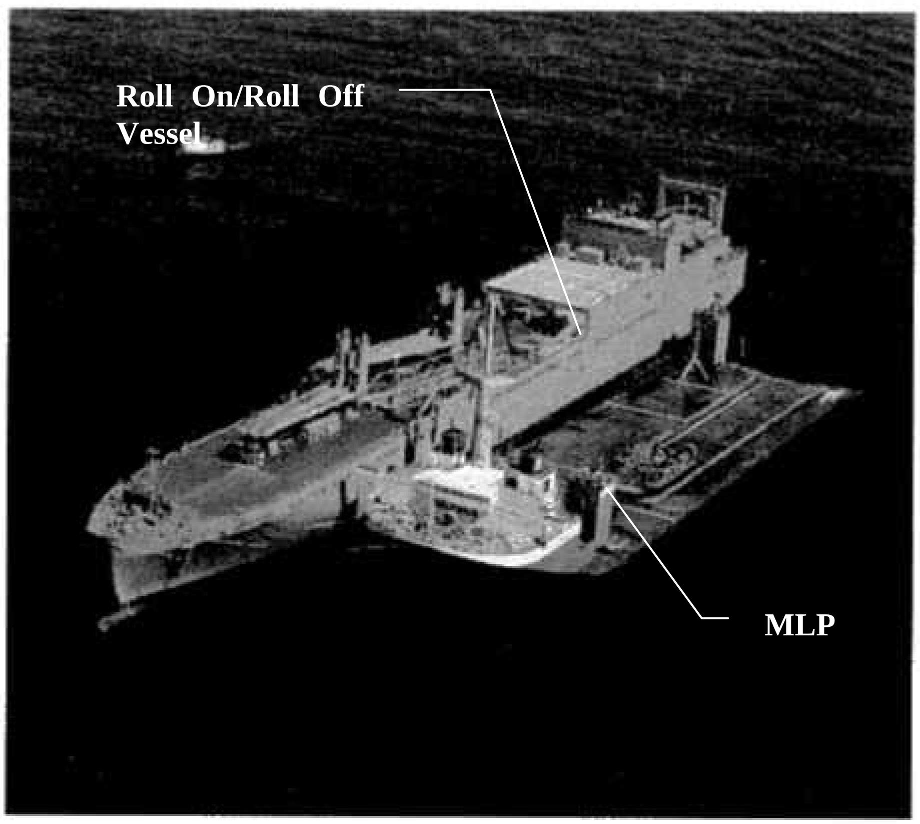

Figure 10. MIGHTY SERVANT 1 and WATKINS Moored Skin-to-Skin From [12]

Length (Overall)	190.03 m
Beam	50.0 m
Draft (Test Cond)	11 m
Displacement (Test Cond)	75,644 LT
Speed	14 kts
Deck Space	10 X 150 m
Deck Load	19-40 tons/m^2

Table 3. MIGHTY SERVANT 1 Characteristics From [12]

B. SURFACE CONNECTORS

1. Landing Craft Air Cushioned (LCAC)

The U.S. Navy's LCAC is the default surface connector in this model even though other connectors will be studied since it represents current capability. The LCAC represents a major revolution in amphibious warfare. A hovercraft by design, it can access over 80% of the world's coastlines whereas a traditional landing craft could only access 17% [13]. In addition, the LCAC's ability to "fly" onto the Mobile Landing Platform (MLP) displayed in Figure 12 makes it an ideal candidate for the Sea Base concept. The load here is limited by the cargo load characteristic rather than the cargo area using standard 1000 lb pallets.

Length (On Cushion)	87 ft 11 in
Beam (On Cushion)	47 ft 0 in
Draft (Off Cushion)	3 ft 0 in
Displacement (Full Load)	200 tons
Speed (w/ payload SS2)	40 kts
Cargo Area	1,809 ft^2
Cargo Load	60 tons/75 tons overload
Range	200 nm w/ payload,40kts

Table 4. LCAC Characteristics From [13]

Figure 11. Landing Craft – Air Cushioned From [13]

Figure 12. LCAC onboard Mobile Landing Platform From [12]

2. Next Generation LCAC (LCAC(X))

Next Generation LCAC has gone thru several iterations including Heavy Lift Craft, Air Cushioned (HLCAC) and the LCAC Replacement Tactical Assault Connector (LCAC(X)) [13]. The Next Generation LCAC, whatever it may be called, will undergo experimentation using the characteristics in Table 5. The result of that experimentation will determine if LCAC(X) is a viable alternative to current capability.

Length (On Cushion)	124.5 ft
Beam (On Cushion)	47 ft 0 in
Draft (Off Cushion)	3 ft 0 in
Speed (w/ payload SS2)	40 kts
Cargo Load	150 tons
Range	200 nm w/ payload,40kts

Table 5. Next Generation LCAC (LCAC(X)) Characteristics From [13]

3. Sea Base Connector Transformable Craft (T-Craft)

The Sea Base Connector Transformable Craft is a request for proposal from the Office of Naval Research with the ability to self deploy from an advance base to the Sea Base and serve as an assault connector and/or logistics connector able to deliver an objective of 5,500 sqft of payload with a maximum weight of 750 LT [14]. The T-Craft is also expected to have an amphibious capability most likely existing in a LCAC type skirt. The payload with the T-Craft using standard 1000 lb pallets is limited by the deck space and the following characteristics will be used:

Length (On Cushion)	120 ft
Beam (On Cushion)	60 ft
Speed (w/ payload SS2)	40 kts
Cargo Load (deck space limited)	206 tons
Range	500 nm w/ payload,40kts

Table 6. T-Craft Characteristics From [14]

Figure 13. T-Craft From [14]

4. Joint High Speed Vessel (JHSV)

The Joint High Speed Vessel (JHSV) is another surface connector that will be studied initially in order to find the advantages and disadvantages of adding a larger connector that takes longer to load and unload but holds more cargo. Based upon Austal's aluminum catamaran design (Figures 14 and 15) this system has already proved its value in the Pacific theater by providing high speed intra-theater sea lift (equal to 245 C-17 sorties) [15].

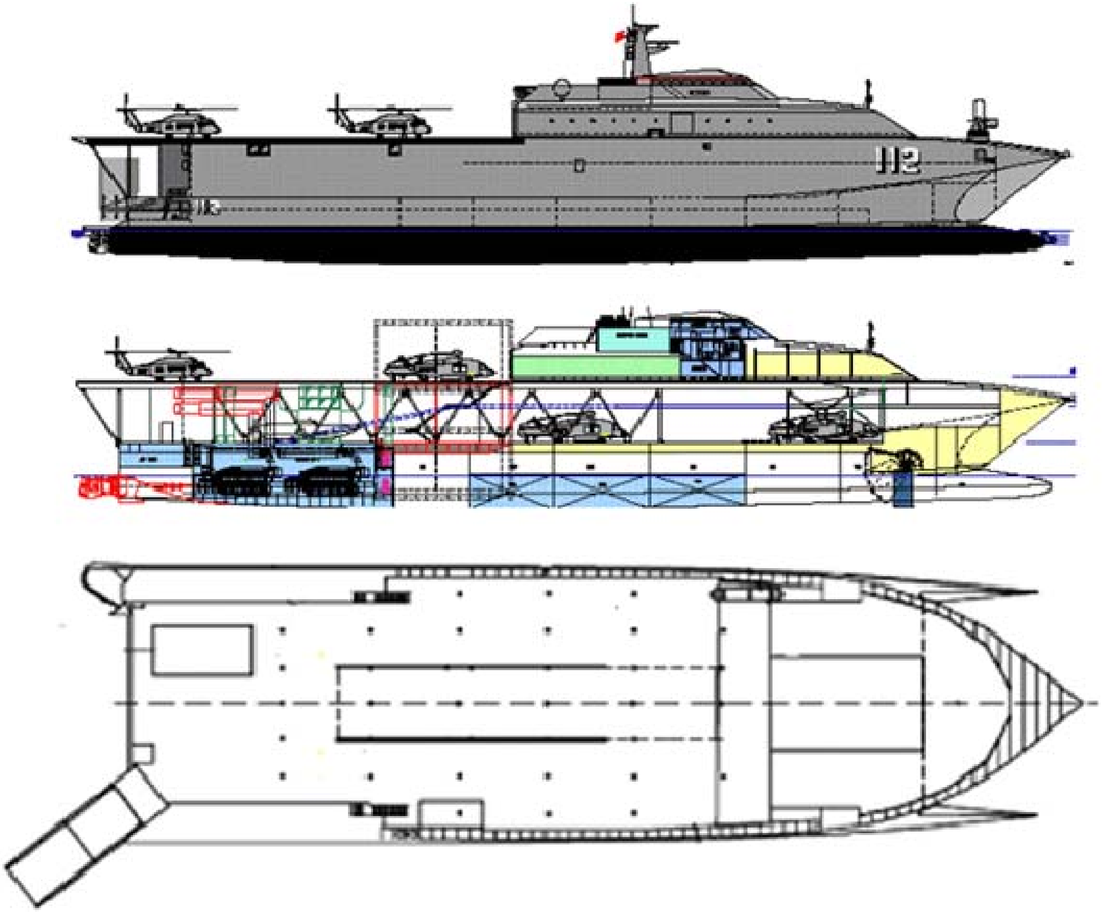

Figure 14. Joint High Speed Vessel (JHSV) Schematic From [15]

The Joint High Speed Vessel (JHSV) is given the following characteristics:

Length	101 m
Beam	26.65 m
Draft	4.2 m
Speed	40 kts
Cargo Load	600 tons
Range	4,500 nm

Table 7. Joint High Speed Vessel Characteristics From [15]

Figure 15. High Speed Vessel (HSV) From [15]

C. AIR CONNECTORS

1. MV-22 Osprey

The MV-22 Osprey represents the next generation multi-mission aircraft developed for the U.S. Navy, U.S. Marine Corp, and U.S. Special Operations Command. This aircraft utilizes tilt rotor technology to combine the speed, range, and efficiency of turboprop aircraft with the vertical take off, landing, and hover capabilities of a helicopter [16]. The ability of the Osprey to self-deploy makes it ideal for a Sea Base concept and for this model; it is given the following characteristics.

Speed	240 kts
Range	50 nm
Payload	5 tons

Table 8. MV-22 Osprey Characteristics From [17]

Figure 16. MV-22 Osprey From [17]

2. CH-53 Super Stallion

The CH-53E is the U.S. Navy and Marine Corps heavy lift helicopter. Even though earlier variants are being phased out by the MV-22, the CH-53 is the only helicopter in the Marine Corp that can lift several systems including the M-198 howitzer and the Light Armored Vehicle (LAV) and retrieve all Marine Corps and most Navy tactical aircraft [18]. This ability has insured the Super Stallion as a mainstay in the fleet for years to come. The CH-53E is given the following characteristics:

Speed	150 kts
Range	50 nm
Payload	16 tons

Table 9. CH-53E Super Stallion Characteristics From [18]

Figure 17. CH-53E Super Stallion From [18]

3. X-Craft

Future autonomous delivery technology is also represented in the form of the X-Craft. This represents a future capability which will provide for a small, lightweight, autonomous aircraft capable of delivering logistics. Its advantage is the ability to deploy numerous aircraft in theater which would increase flexibility. The X-Craft is given the following characteristics in Table 10 and shown in Figure 18 what such an aircraft might look like.

Speed	240 kts
Range	40 nm
Payload	3 tons

Table 10. X-Craft Characteristics

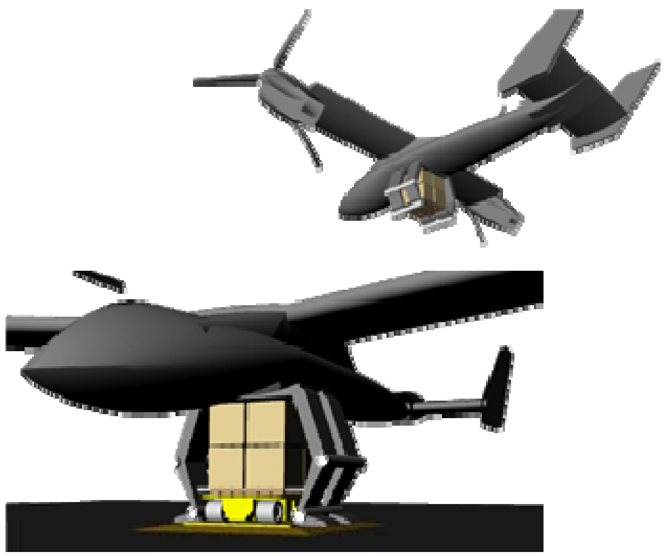

Figure 18. X-Craft From [7]

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V. INITIAL ANALYSIS

A. OVERVIEW OF CONCEPT

An initial analysis of the problem was done to further focus the efforts of this study. The scenario shown in Figure 19 was chosen with a container ship first bringing supplies to a T-AKE class ship. The T-AKE ship then would distribute the supplies as necessary to fleet surface forces, air connectors (CH-53, MV-22, X-Craft), and the Mobile Landing Platform (MLP) which in this case was taken to be MIGHTY SERVANT 1. The MLP then loads supplies to the surface connectors (LCAC, Next Generation LCAC, T-Craft, or JHSV).

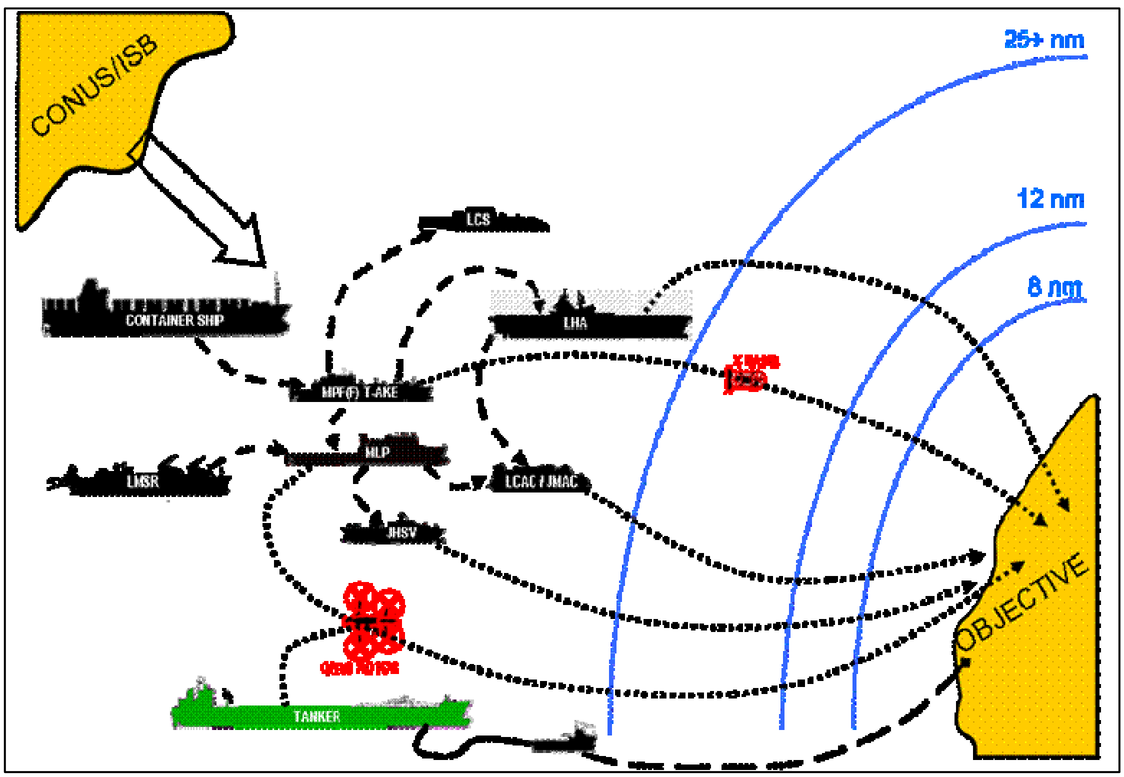

Figure 19. Initial Concept Scenario

The weakest link in the chain concept was used to determine where the choke points were in the supply chain using payload transfer rates and the technologies listed in Chapter III.

B. STAGES

1. Container Ship to T-AKE Transfer

For this portion of the supply chain, the Large to Large Vessel Interface Lift On/Lift Off (LVI LO/LO) crane was assumed to be on the T-AKE transferring containers from the container ship to the T-AKE. A metric of 160 tons/hr was used for the container ship to T-AKE transfer calculated from the metric of 20 lifts per hour and each container containing 16 pallets at 1000 lbs each.

2. T-AKE Internal Flow

The T-AKE internal flow is broken up into several parts. Once the container is placed on the T-AKE, a rate of unloading one container every five minutes is used. With the container containing 16 pallets at 1000 lbs each, a transfer rate of 96 tons/hr is used. After the container is broken out and sent back to the container ship, a combination of High Rate Vertical/Horizontal Material Movement (HRVHMM) and Automated Warehouse (AW) are used with both technologies using a metric of 105 tons/hr for the strike down and subsequent strike up operations to the MLP, the VERTREP stations, and the fleet UNREP stations.

3. T-AKE to MLP Transfer

After striking up the cargo on the T-AKE has been completed it is then transferred from the T-AKE to the MLP via the interface ramp technologies and some sort of Compact Agile Material Mover (CAMM) type technology. A throughput rate of 70 tons/hr is used.

4. T-AKE to Air Connector to Shore

At the same time that cargo is being transferred to the MLP, cargo is also being transferred to the flight deck for transfer via air connectors to the shore. This throughput is calculated by the following:

$$q_{air} = \frac{(N)(P)}{\left[\frac{2D}{V_{air}} + t_L + t_U + 2t_d + 2t_u\right]}$$

where:

q_{air} = Air connector throughput rate (tons/hr)

N = Number of air connectors

P = Air connector payload (tons)

D = Distance to objective (nm)

V_{air} = Air connector speed (kts)

t_L = Connector load time (hr)

t_U = Connector unload time (hr)

t_d = Connector docking time (hr)

t_u = Connector undocking time (hr)

5. T-AKE to Fleet UNREP

It is also assumed that the T-AKE will have underway replenishment (UNREP) responsibilities with the fleet of amphibious ships and surface combatants safeguarding the Sea Base. The number is estimated to be six ships in a standard expeditionary strike group, with three days between UNREPs and 300 tons transferred to each ship per UNREP evolution.

6. MLP to Sea Connector to Shore

In order to establish the transfer rate for the surface connectors, it must be established whether or not a wait time exists. Wait time is defined as the period of time that a surface connector must wait upon returning to the MLP due to another connector in its spot. The LCAC is used as an example and the wait time at a single loading spot is calculated as:

$$t_w = t_L(N-1) - (t_{u1} + 2t_T + t_{d2} + t_U + t_{u2} + t_{d1}) \text{ (single loading spot)}$$

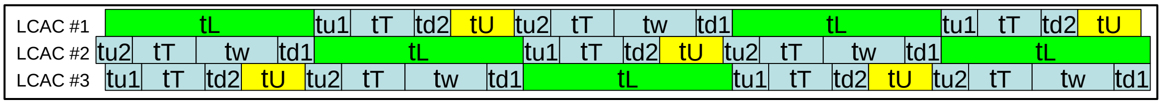

Figure 20. Single Loading Spot Timeline

$t_w =$ Connector wait time (hr)
$N =$ Number of air connectors
$t_L =$ Connector load time (hr)
$t_U =$ Connector unload time (hr)
$t_{d1} =$ Connector/MLP docking time (hr)
$t_{u1} =$ Connector/MLP undocking time (hr)
$t_{d2} =$ Connector/objective docking time (hr)
$t_{u2} =$ Connector/objective undocking time (hr)
$t_T =$ One way transit time to objective (hr)

where t_L is defined as the time to load one connector while on the MLP. N is defined as the number of connectors. t_{d1} and t_{u1} are defined as the docking and undocking time respectively for a single connector at the MLP whereas t_{d2} and t_{u2} are the docking and undocking times at the shore. t_T is defined as the one way transit time to the beach calculated as the distance to the shore divided by the speed of the connector. t_U is the time to unload one connector at the beach. The timeline above (Figure 20) provides a visual representation of this situation. In the case of multiple loading spots the variable n_l is introduced which is the number of loading spots. A new variable is calculated as:

$$m_l = \frac{N}{n_l}$$

and round up to the next integer. The new wait time is then calculated as:

$$t_w = t_L(m_l - 1) - (t_{u1} + 2t_T + t_{d2} + t_U + t_{u2} + t_{d1}) \text{ (multiple loading spots)}$$

If t_w is greater than zero then there is a wait time and the limiting factor is the rate of loading on the MLP (Q_L). This is calculated as:

$$Q_L = \frac{n_l P}{t_L}$$

where P is defined as the cargo carrying ability of the connector.

If t_w is less than or equal to zero it is then set to zero. This situation is seen in Figure 21 and the connector transfer rate is the limiting factor. This is calculated as:

$$Q_t = \frac{NP}{(t_L + t_{u1} + 2t_T + t_{d2} + t_U + t_{u2} + t_{d1})}$$

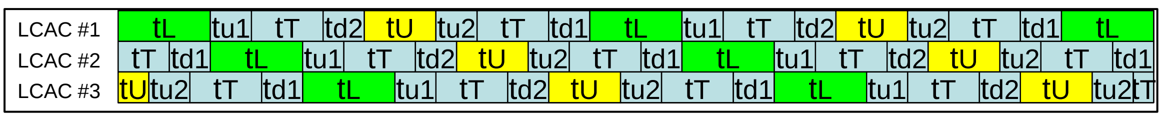

Figure 21. Single Loading Spot (No Wait Time)

A simple timeline test was conducted to test the accuracy of the calculation as seen in Figure 22.

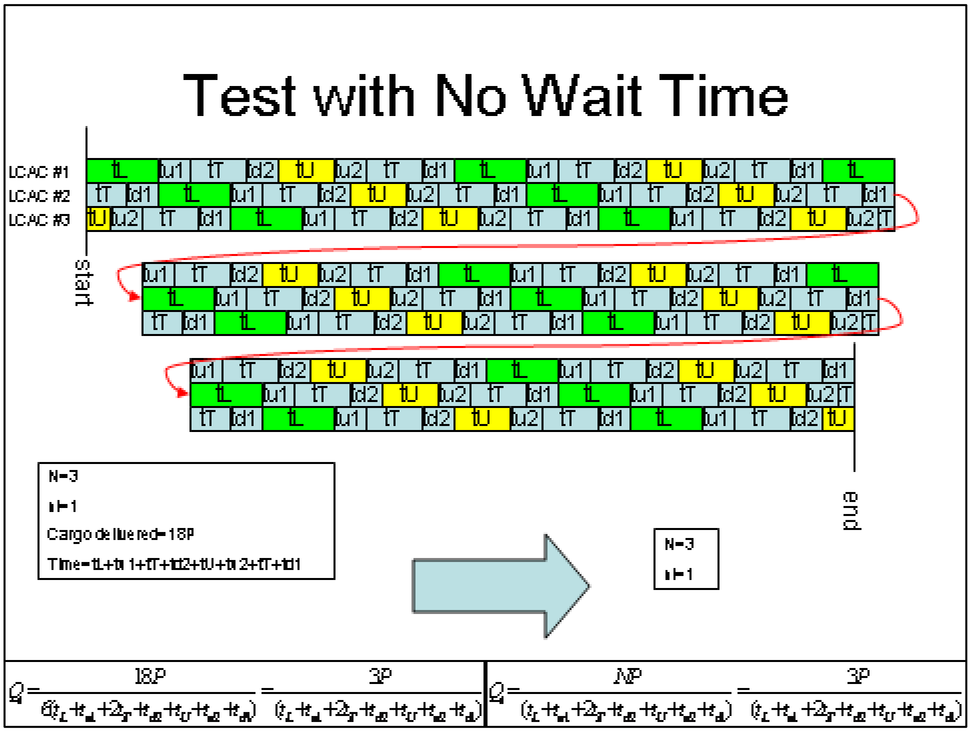

Figure 22. Test with No Wait Time

C. RESULTS

Several cases were run with this model using different combinations of surface and air connectors. Figure 23 shows a typical result for the initial analysis. Even with each of the technologies discussed earlier, the T-AKE overall seems to be a weak link in the throughput rate (as indicated by the circle).

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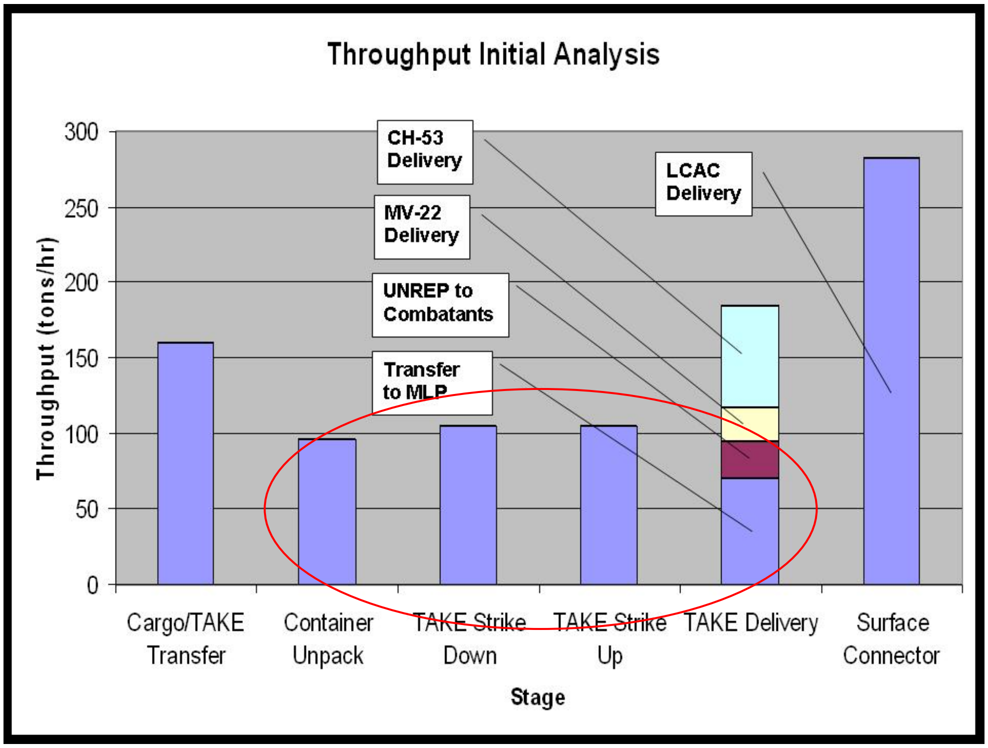

Figure 23. Initial Throughput Analysis

Incidentally, statements made by Geoff Main of the Office of Naval Research in June 2008 indicated that there were problems with placing a ramp on the T-AKE and that the Navy was now looking at placing the Large to Large Vessel Interface Lift On/Lift Off (LVI LO/LO) crane on the Mobile Landing Platform (MLP) [19]. This would enable transfer from the container ship directly to the MLP thereby cutting out the T-AKE totally, enabling it to focus on its fleet underway replenishment duties not only at the Sea Base but in the entire area of responsibility (AOR). Additionally it is seen that the surface connector stage dominates the throughput. To more fully understand this, further study is conducted in Chapter VI.

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VI. MLP MODELING

A. OVERVIEW OF CONCEPT

Once the T-AKE is eliminated, the Mobile Landing Platform (MLP) is now the limiting platform and attention is now turned towards optimizing this link in the chain. The throughput on the MLP is a factor of the number and type of surface connectors used, the number of loading spots, and the loading time per connector. The purpose of this model is to determine the maximum amount of connectors that may be employed without saturating the system and causing connector wait times. Again, wait time is defined as the period of time that a surface connector must wait upon returning to the MLP due to another connector in its spot. A program was developed with MATLAB using with the equations explained in Chapter V to model this portion of the logistical chain and the results will be shown in Section C.

It is expected that with an increase in the load rate, the load time will decrease causing an increase in the amount of connectors that can be used. As the distance to the objective increase, the amount of connectors should also increase to compensate for longer transit times. As larger connectors are used, it is also expected that less will be able to be employed due to increased area required for each loading spot and longer load times required for the same load rate.

1. Connectors Used

Three different connectors, the Landing Craft-Air Cushioned (LCAC) currently in service with the United States Navy, the Next Generation LCAC (LCAC(X)), and the Sea Base Connector Transformable Craft (T-Craft) as described in Section X will be used in the model. Their characteristics are shown below.

a. Landing Craft Air Cushioned LCAC

Length (On Cushion)	87 ft 11 in
Beam (On Cushion)	47 ft 0 in
Draft (Off Cushion)	3 ft 0 in
Displacement (Full Load)	200 tons
Speed (w/ payload SS2)	40 kts
Cargo Area	1,809 ft^2
Cargo Load	60 tons/75 tons overload
Range	200 nm w/ payload, 40 kts

Table 11. LCAC Characteristics [13]

b. Next Generation Landing Craft Air Cushioned (LCAC(X))

Length (On Cushion)	124.5 ft
Beam (On Cushion)	47 ft 0 in
Draft (Off Cushion)	3 ft 0 in
Speed (w/ payload SS2)	40 kts
Cargo Load	150 tons
Range	200 nm w/ payload, 40 kts

Table 12. LCAC(X) Characteristics [13]

c. Sea Base Connector Transformable Craft (T-Craft)

Length (On Cushion)	120 ft
Beam (On Cushion)	60 ft
Speed (w/ payload SS2)	40 kts
Cargo Load (deck space limited)	206 tons
Range	500 nm w/ payload, 40 kts

Table 13. T-Craft Characteristics [14]

2. Overview of MLP Deck Space

To calculate the deck space available for cargo storage on the MLP, the MIGHTY SERVANT 1 is used as a prototype with a listed deck space of 50 X 150 meters [20]. The LVI LOLO crane is assumed to take a quarter of the available deck space which makes the total space available for pallets, the aisles between the pallets and loading spots to be 60547 ft^2. A standard navy pallet size is used for uniformity as shown in Table 14.

Length	48 in
Width	40 in
Area	13.33 ft^2
Weight	1000 lbs

Table 14. Standard Pallet Size From [21]

In addition, the deck area was calculated for the pallets being stacked one or two high (which effectively doubles the deck area). To account for the aisles between the rows of pallets, a pallet length of 48 in. and a standard forklift turning radius of 102.4 in. is taken to calculate a pallet density of .4839 [22]. With this, an equation is developed for available deck space below.

$$A = b\eta(D - an)$$

$$C = \frac{b\eta(D - an)w}{d}$$

where:

A = Cargo Deck Space (ft^2)

C = Cargo Stowage (tons)

b = Pallet Stack Size

η = Pallet/Deck Area Density

D = Available Deck Space (ft^2)

a = Loading Spot Area (ft^2)

n = Number of Loading Spots

w = Pallet Weight (tons)

d = Pallet Area (ft^2)

The area taken up per loading spot was calculated to be:

Connector	Loading Spot Area
LCAC	6336 ft^2
LCAC(X)	7476 ft^2
T-Craft	10080 ft^2

Table 15. Loading Spot Areas

A limit is reached in the amount of loading spots that can be place side by side along the length of the MLP and the following is found:

$$n = \frac{\text{MLP Deck Length}}{\text{Loading Spot Width}}$$

Connector	Loading Spot Limit
LCAC	8
LCAC(X)	8
T-Craft	7

Table 16. Loading Spot Limit

Ultimately the MLP cargo carrying capability is calculated as:

MLP Deck Space (Pallets 1 high)	LCAC		HLCAC		T-Craft	
Loading Spots	Deck Area (ft^2)	Cargo (tons)	Deck Area (ft^2)	Cargo (tons)	Deck Area (ft^2)	Cargo (tons)
1	26233	984	25681	963	24421	916
2	23167	869	22063	828	19543	733
3	20101	754	18446	692	14666	550
4	17035	639	14828	556	9788	367
5	13969	524	11211	420	4910	184
6	10903	409	7593	285	32	1
7	7837	294	3975	149	0	0
8	4771	179	358	13		
MLP Deck Space (Pallets 2 high)	LCAC		HLCAC		T-Craft	
Loading Spots	Deck Area (ft^2)	Cargo (tons)	Deck Area (ft^2)	Cargo (tons)	Deck Area (ft^2)	Cargo (tons)
1	52465	1968	51362	1927	48842	1832
2	46333	1738	44127	1655	39087	1466
3	40201	1508	36892	1384	29331	1100
4	34069	1278	29656	1112	19576	734
5	27937	1048	22421	841	9820	368
6	21806	818	15186	570	65	2
7	15674	588	7950	298	0	0
8	9542	358	715	27		

Table 17. MLP Cargo Carrying Capability

B. RESULTS

1. Landing Craft Air Cushioned LCAC

Applicable results are shown below for both the 10 nautical mile and the 25 nautical mile distances to the objective. Runs were conducted varying the number of LCACs from 10 to 70 at 10 nm and 10 to 80 LCACs at a distance of 25 nm to observe the maximum number of surface connectors that could be used given the number of loading spots compared to the MLP storage capacity for various load rates. In this case 60 tons/hr represents the current load rate, while 80 tons/hr represents an increase of 33% in the load rate. 100 tons/hr represents an increase of 66% and of course 120 tons/hr is a doubling of the load rate. By doing this it is hoped to be shown whether or not investments in technologies which increase the load rates of the various surface connectors would be worth while.

a. 10 nm

In Figure 24, it is shown that with 34 LCACs at a distance of 10 nm, 60 tons/hr load rate, and seven loading spots, approximately 270 tons of MLP storage is required. This is well below the 294 tons that is calculated in Section A for normal deck space and seven loading spots. If the number of LCACs is increased to 36 as shown in Figure 25, eight loading spots are now required which then decreases the available deck space to 179 tons which is not enough to account for the approximately 290 tons now needed. The rest of the cases were evaluated in the same manner for each of the connectors for the 10 nm and 25 nm distances to the objective, the various load rates listed above, and normal and double deck space. The results are then tabulated in Tables 18 and 19.

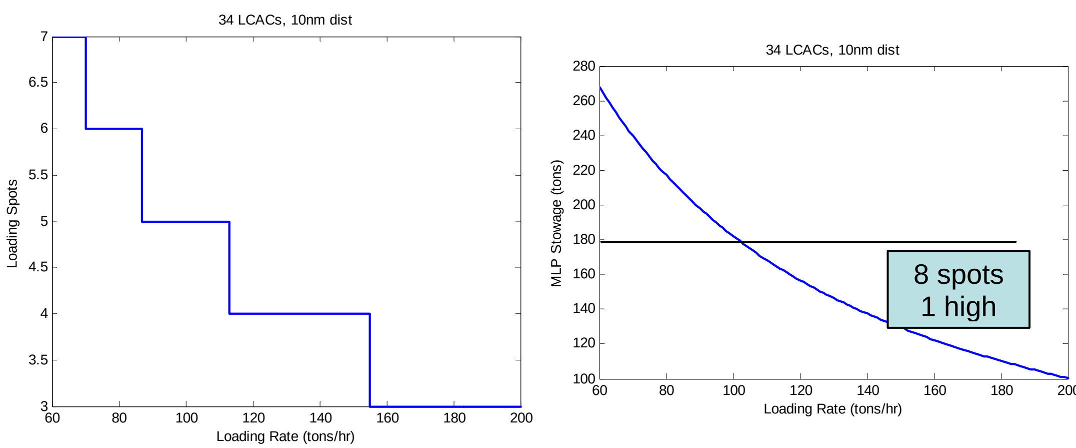

Figure 24. Case #13 / 34 LCACs / 10 nm

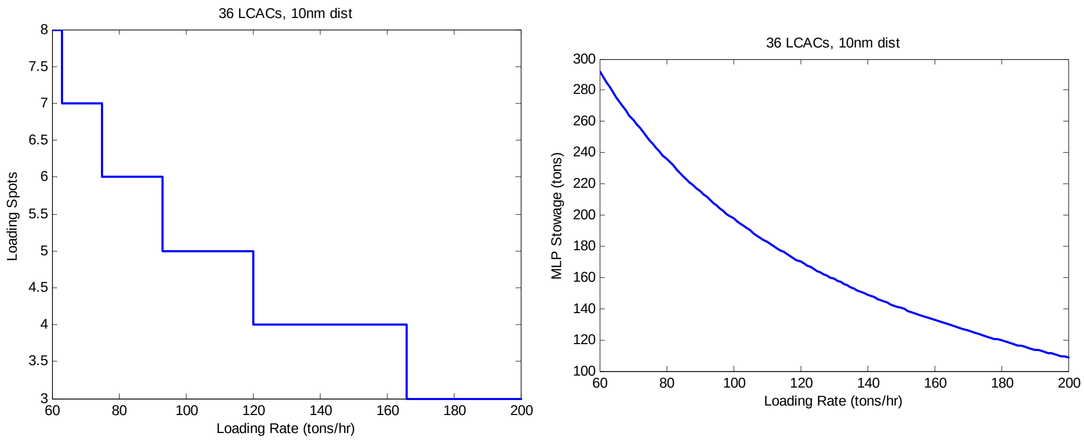

Figure 25. Case #14 / 36 LCACs / 10 nm

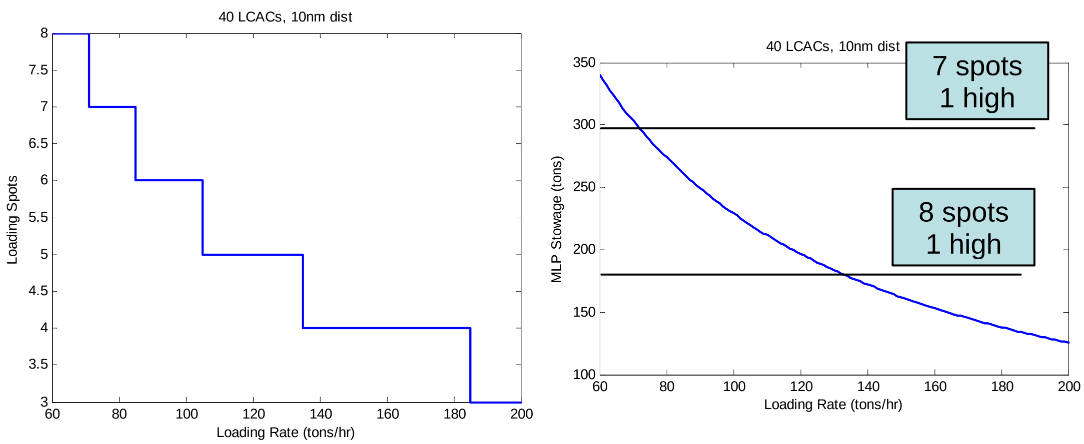

Figure 26. Case #16 / 40 LCACs/ 10 nm

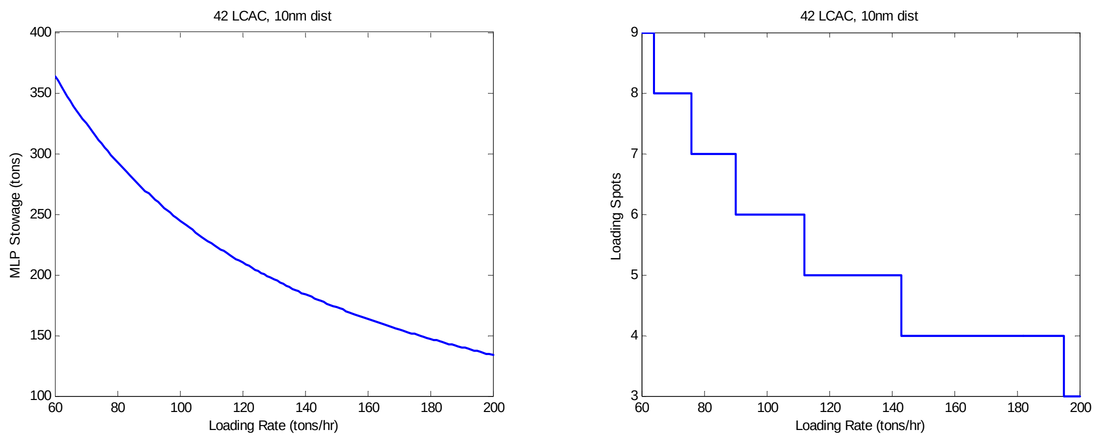

Figure 27. Case #17 / 42 LCACs/ 10 nm

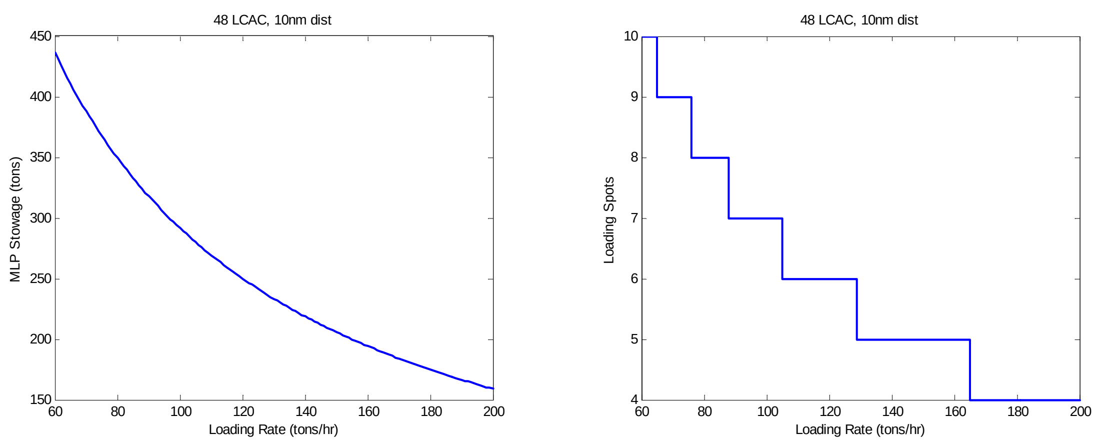

Figure 28. Case #20 / 48 LCACs/ 10 nm

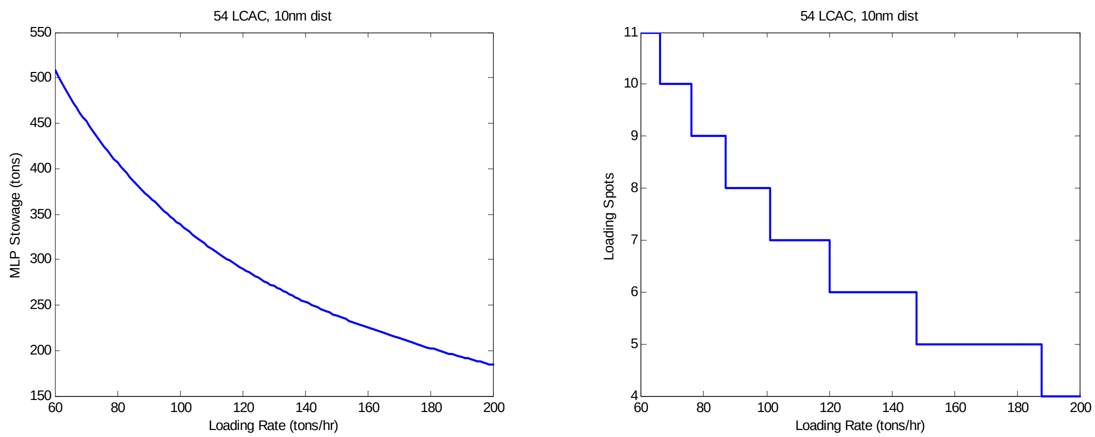

Figure 29. Case #23 / 54 LCACs/ 10 nm

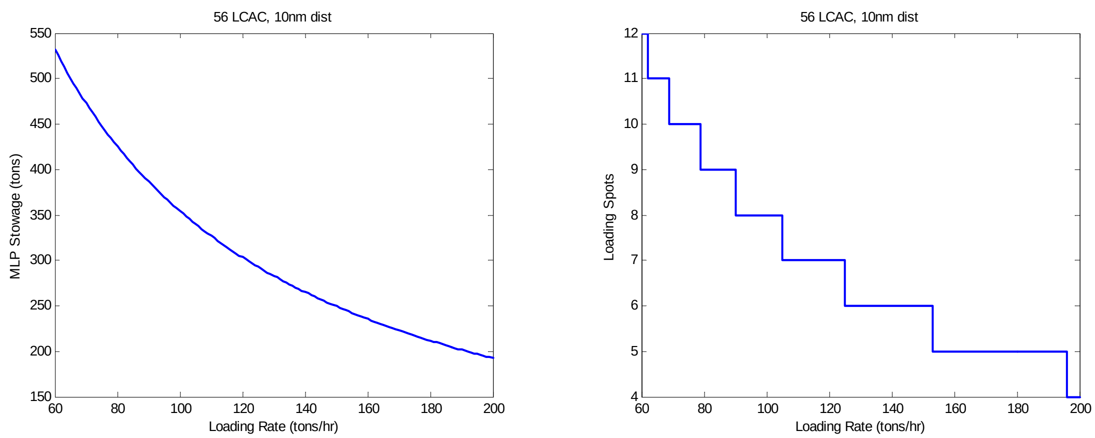

Figure 30. Case #24 / 56 LCACs/ 10 nm

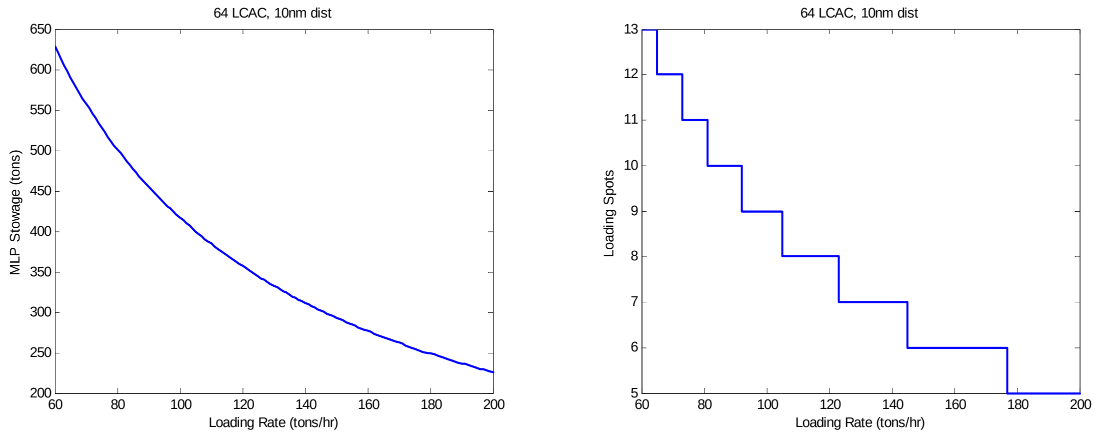

Figure 31. Case #29 / 64 LCACs/ 10 nm

b. 25 nm

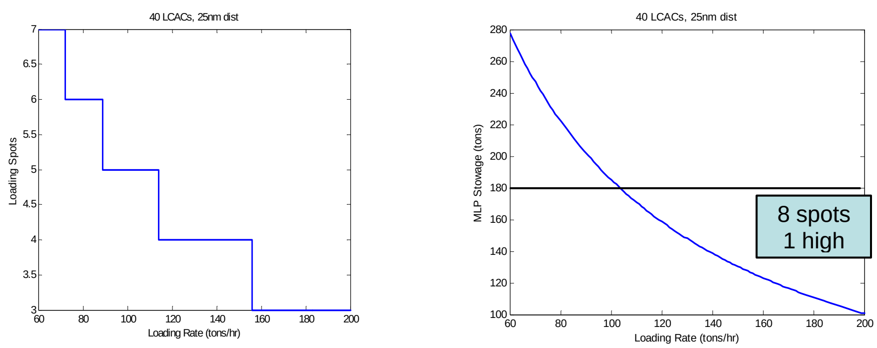

Figure 32. Case #48 / 40 LCACs / 25 nm

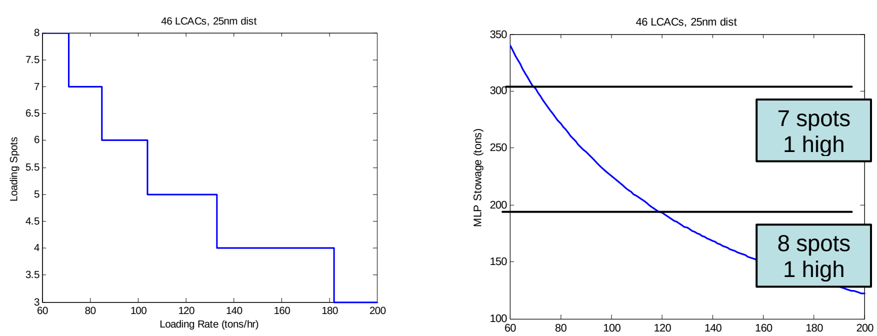

Figure 33. Case #51 / 46 LCACs / 25 nm

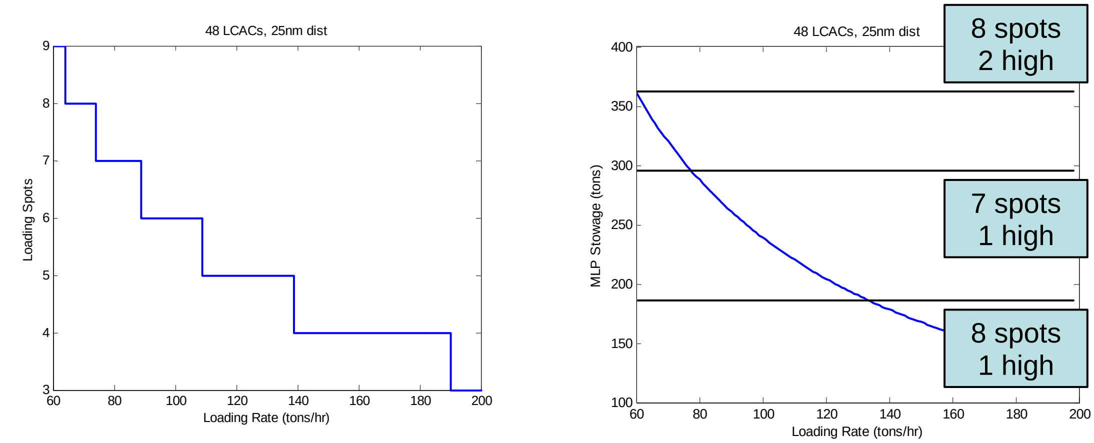

Figure 34. Case #52 / 48 LCACs / 25 nm

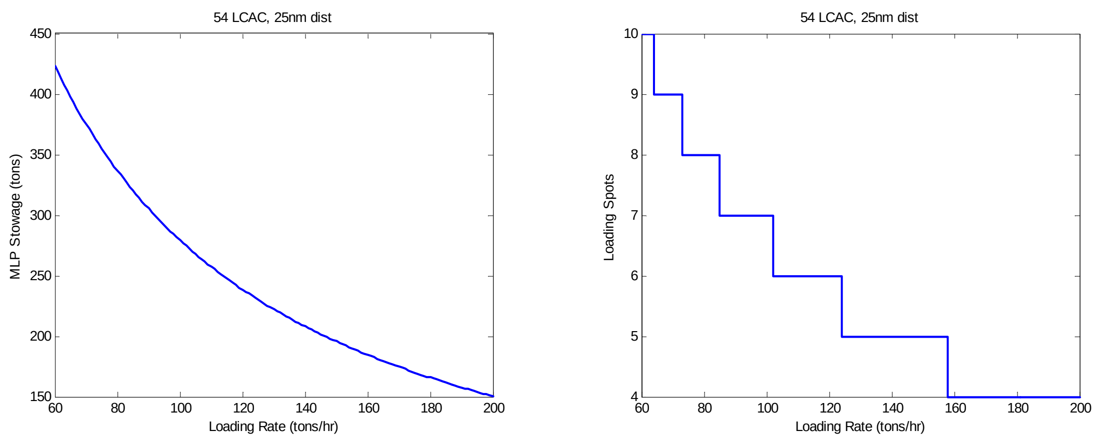

Figure 35. Case #55 / 54 LCACs / 25 nm

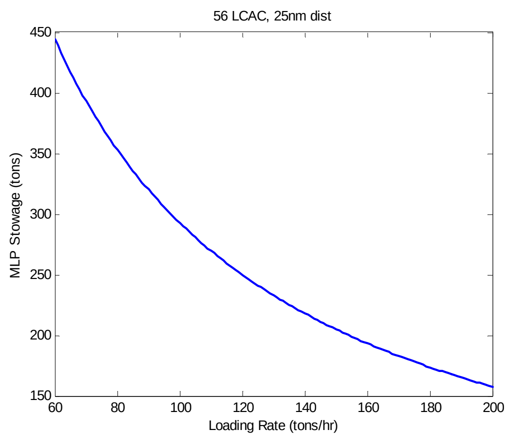

Figure 36. Case #56 / 56 LCACs / 25 nm

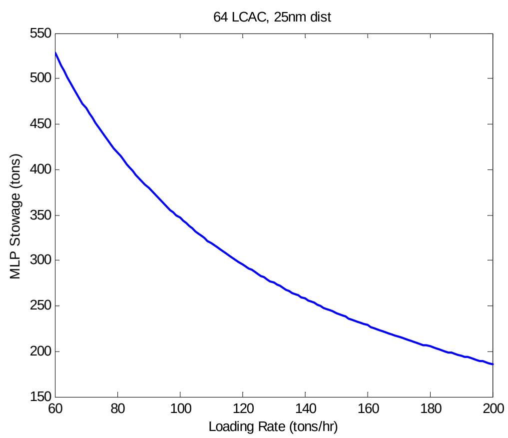

Figure 37. Case #60 / 64 LCACs / 25 nm

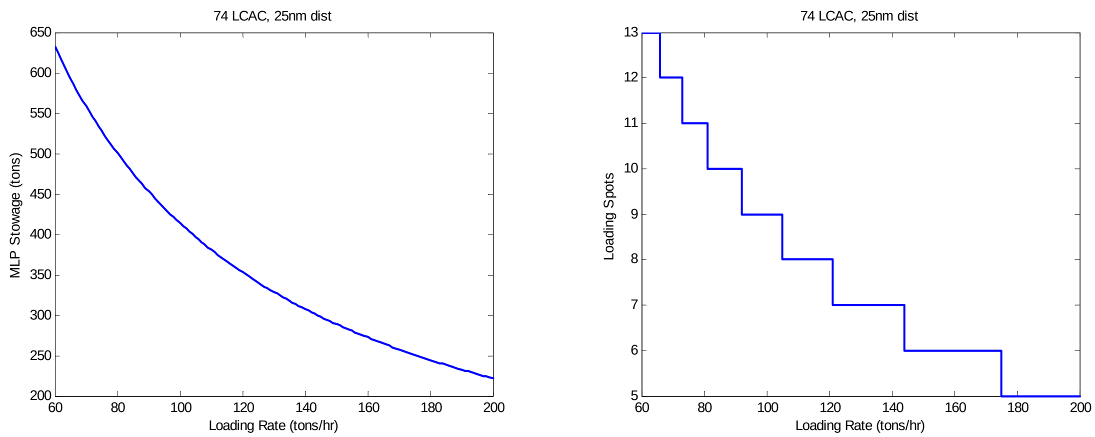

Figure 38. Case #65 / 74 LCACs / 25 nm

2. Next Generation Landing Craft Air Cushioned (LCAC(X))

The Next Generation Landing Craft Air Cushioned was evaluated in the same manner as the LCAC. Applicable results are shown below for the 10 and 25 nm cases and again tabulated in Tables 18 and 19.

a. 10 nm

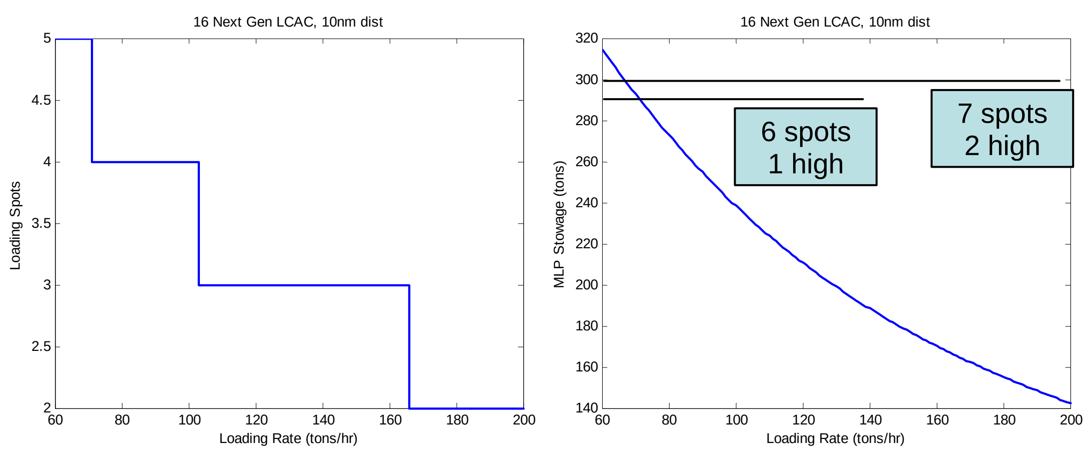

Figure 39. Case #74 / 16 Next Generation LCACs / 10 nm

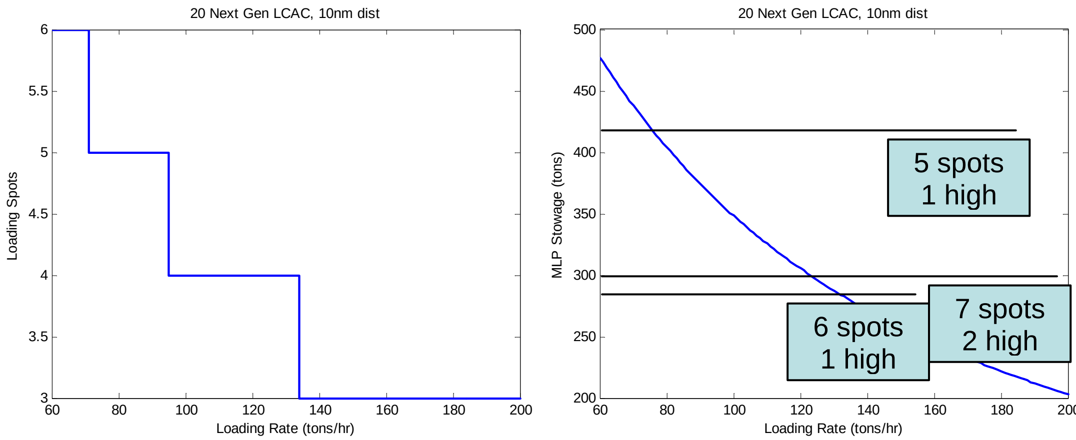

Figure 40. Case #76 / 20 Next Generation LCACs / 10 nm

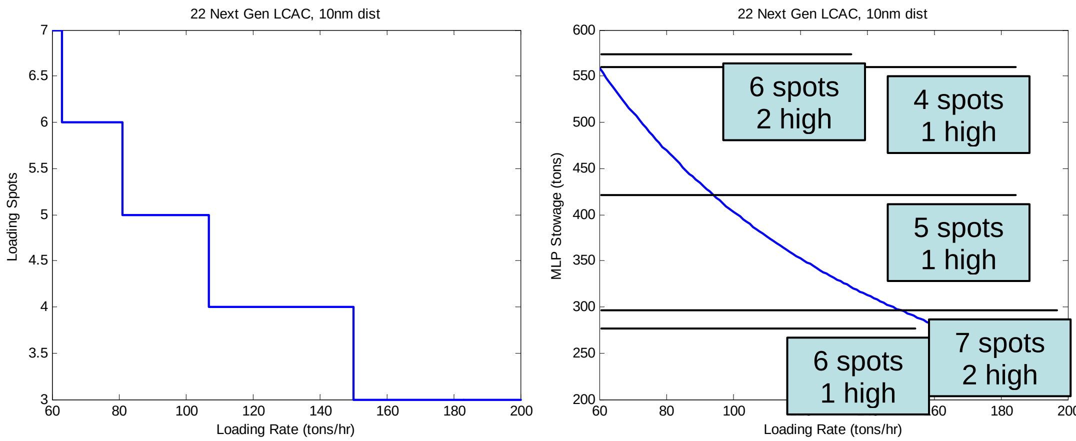

Figure 41. Case #77 / 22 Next Generation LCACs / 10 nm

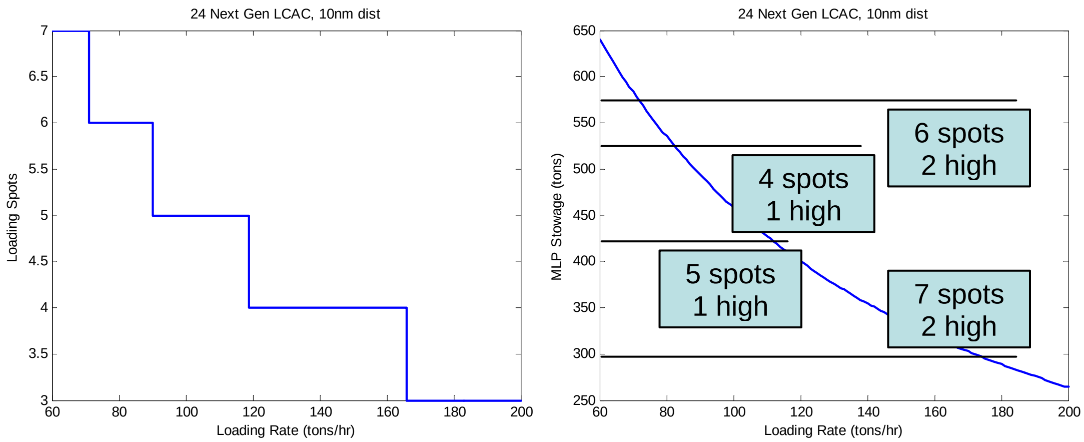

Figure 42. Case #78 / 24 Next Generation LCACs / 10 nm

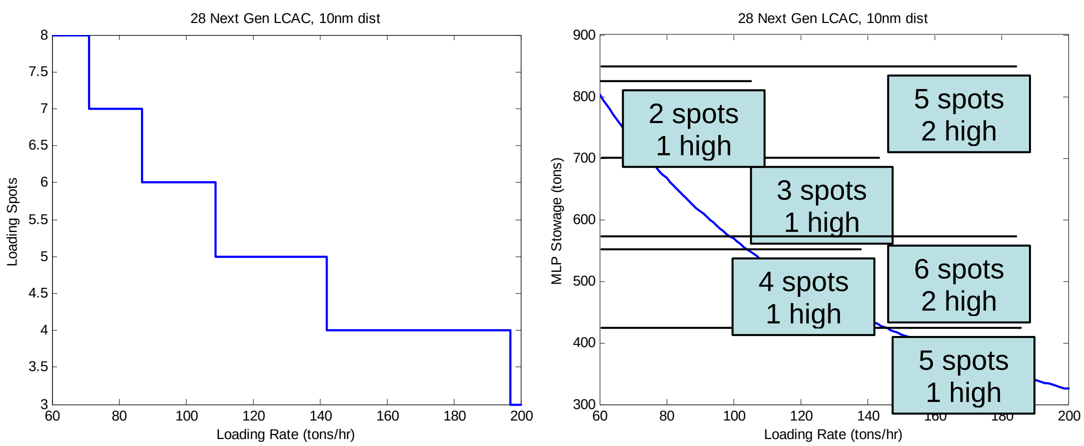

Figure 43. Case #80 / 28 Next Generation LCACs / 10 nm

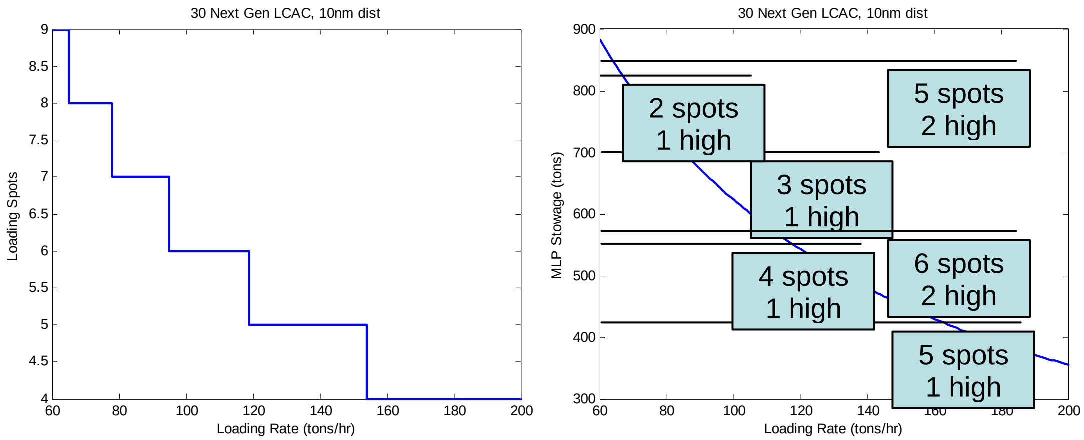

Figure 44. Case #81 / 30 Next Generation LCACs / 10 nm

b. 25 nm

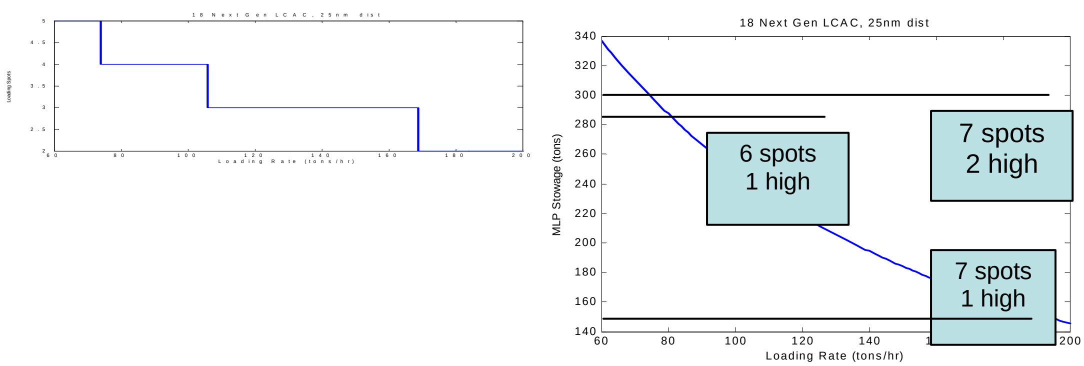

Figure 45. Case #93 / 18 Next Generation LCACs / 25 nm

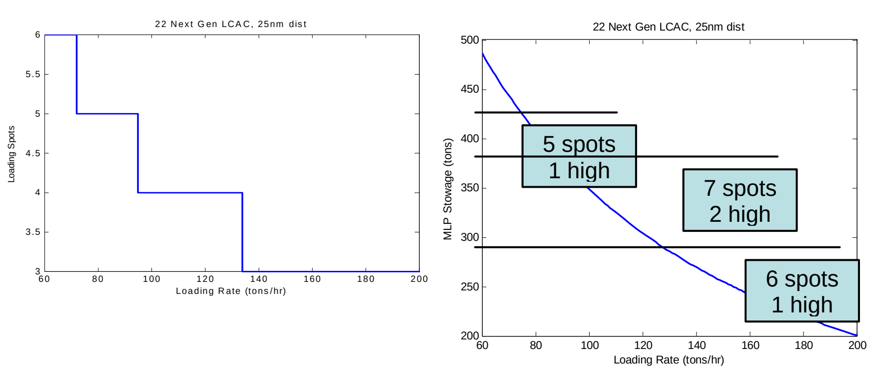

Figure 46. Case #95 / 22 Next Generation LCACs / 25 nm

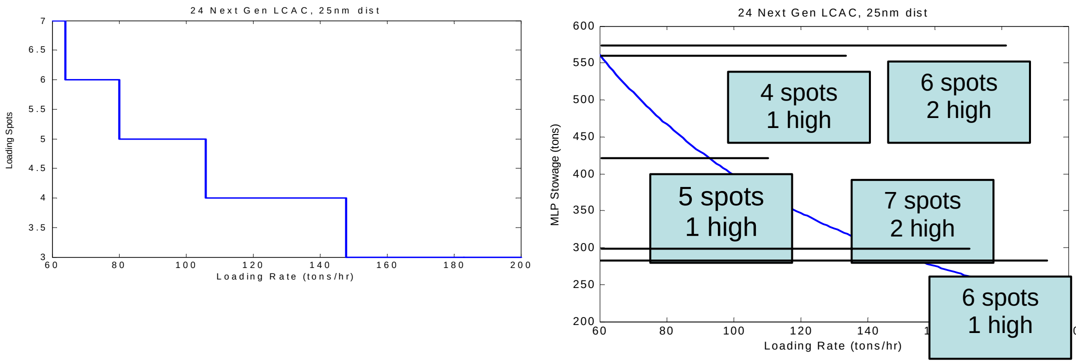

Figure 47. Case #96 / 24 Next Generation LCACs / 25 nm

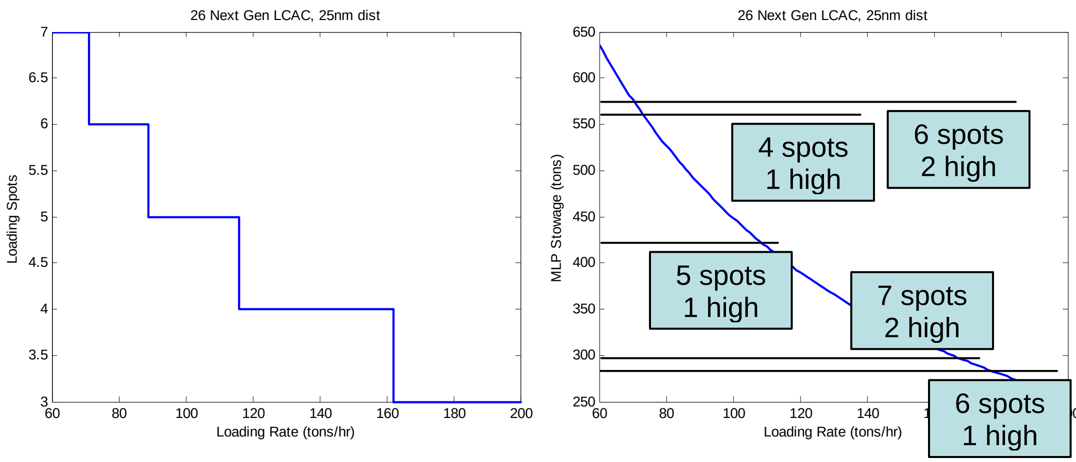

Figure 48. Case #97 / 26 Next Generation LCACs / 25 nm

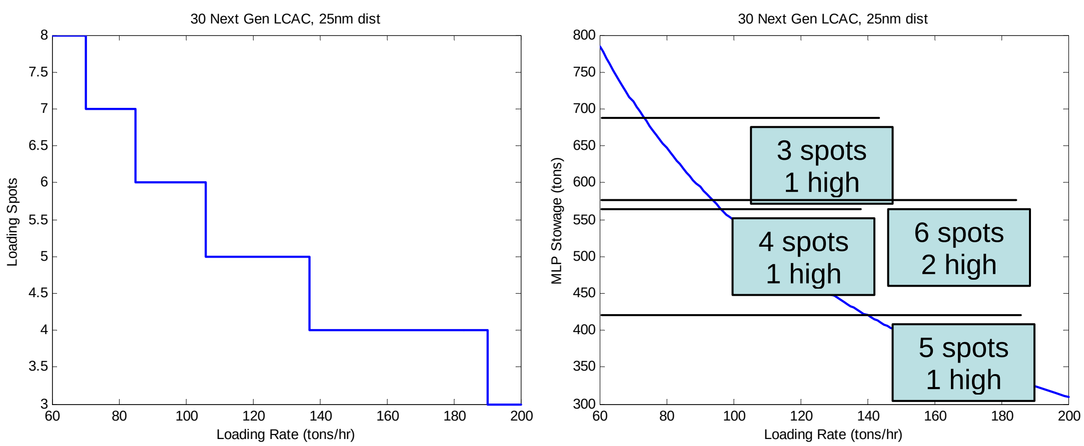

Figure 49. Case #99 / 30 Next Generation LCACs / 25 nm

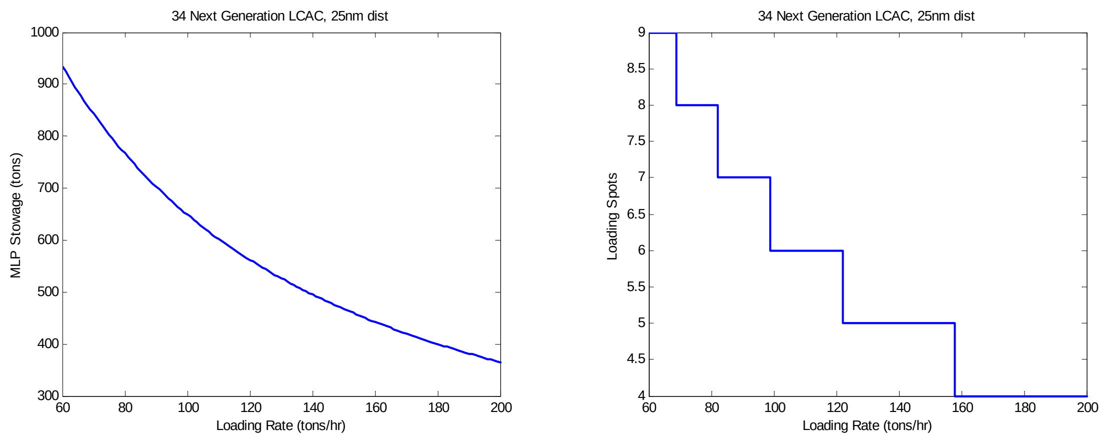

Figure 50. Case #101 / 34 Next Generation LCACs / 25 nm

3. T-Craft

The T-Craft was evaluated in the same manner as the LCAC and the LCAC(X). Applicable results are shown below for the 10 and 25 nm cases and again tabulated in Tables 18 and 19.

a. 10 nm

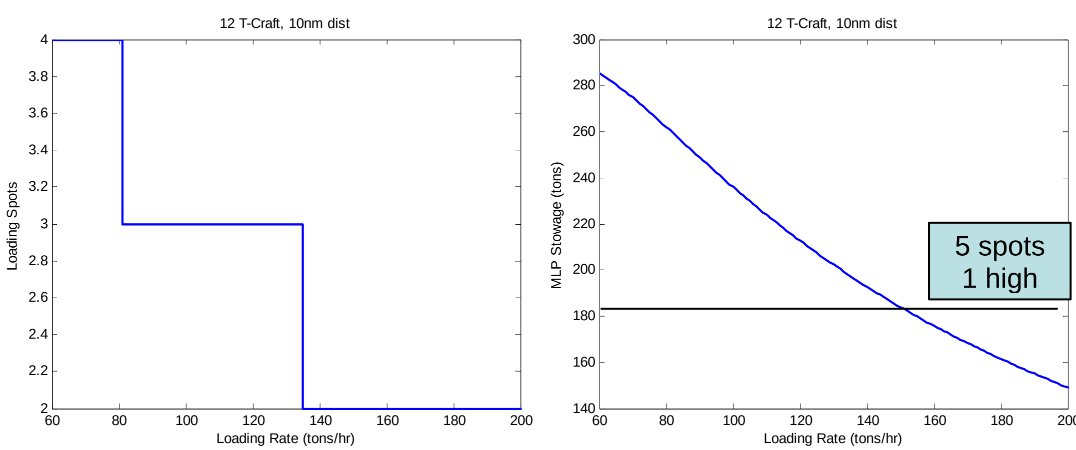

Figure 51. Case #108 / 12 T-Craft / 10 nm

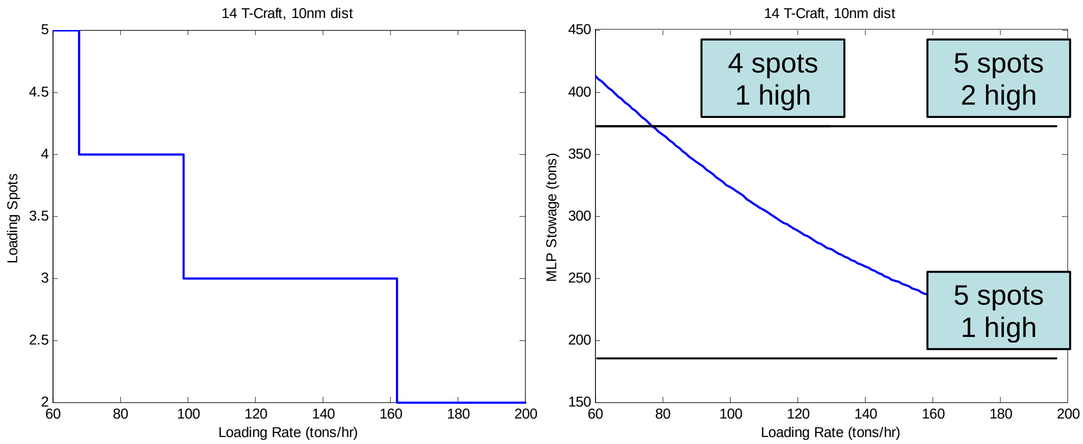

Figure 52. Case #109 / 14 T-Craft / 10 nm

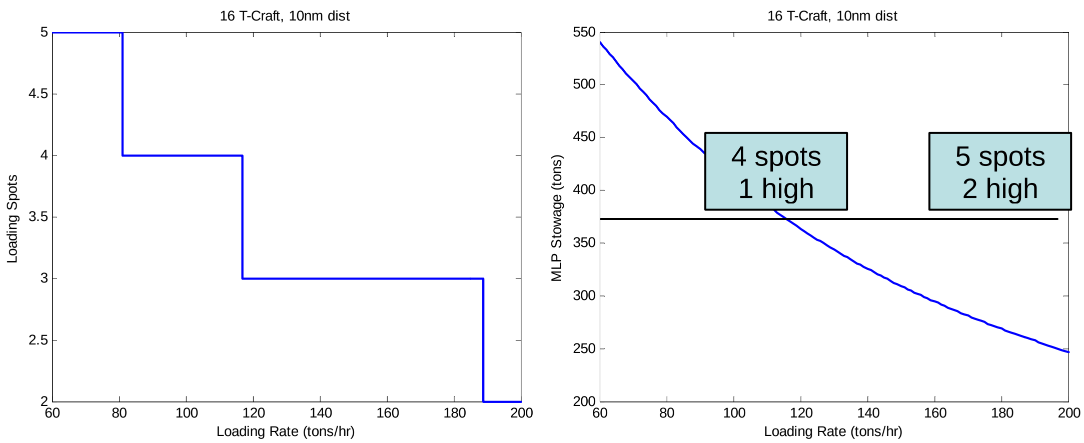

Figure 53. Case #110 / 16 T-Craft / 10 nm

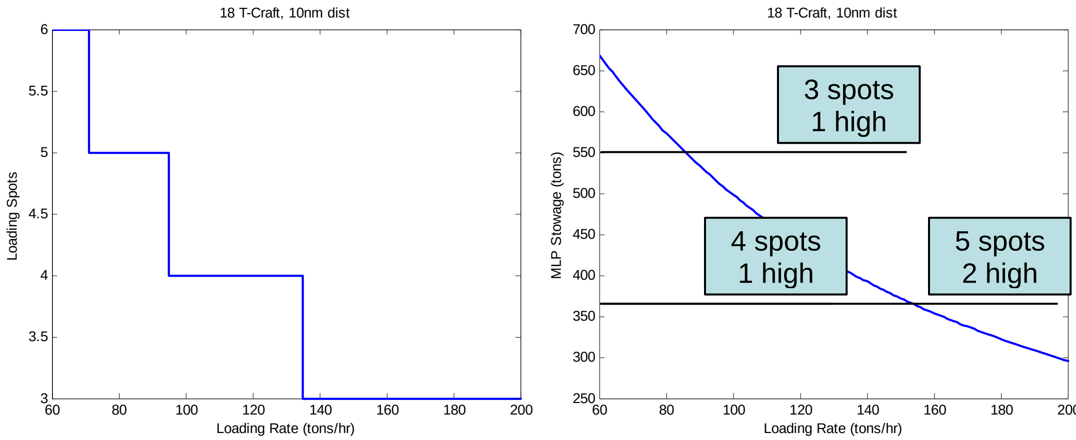

Figure 54. Case #111 / 18 T-Craft / 10 nm

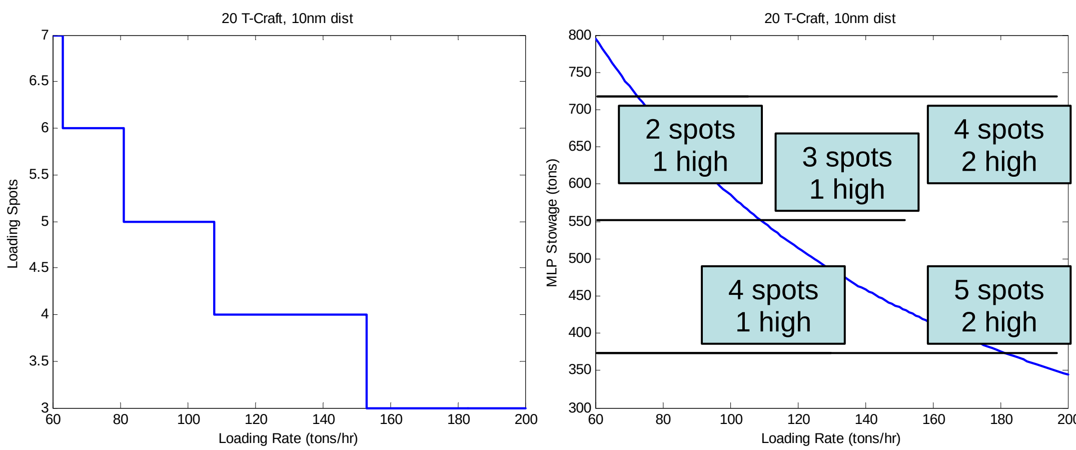

Figure 55. Case #112 / 20 T-Craft / 10 nm

b. 25 nm

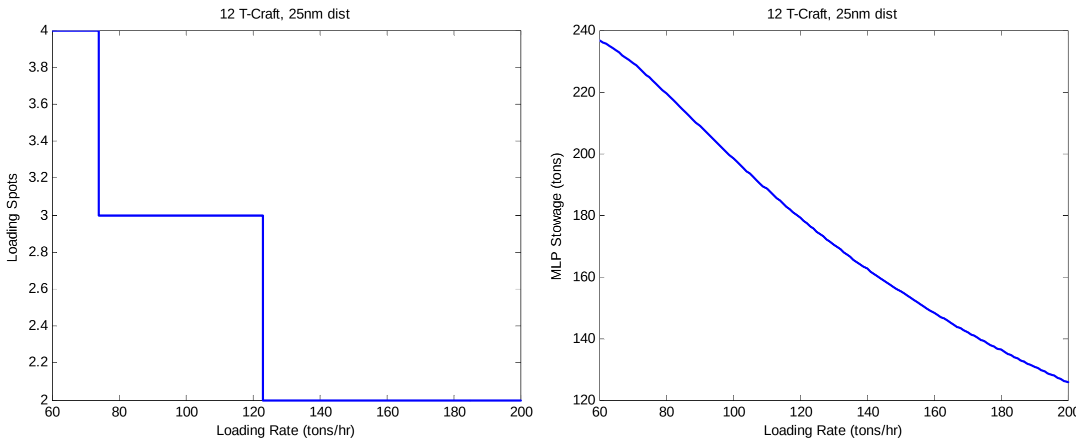

Figure 56. Case #121 / 12 T-Craft / 25 nm

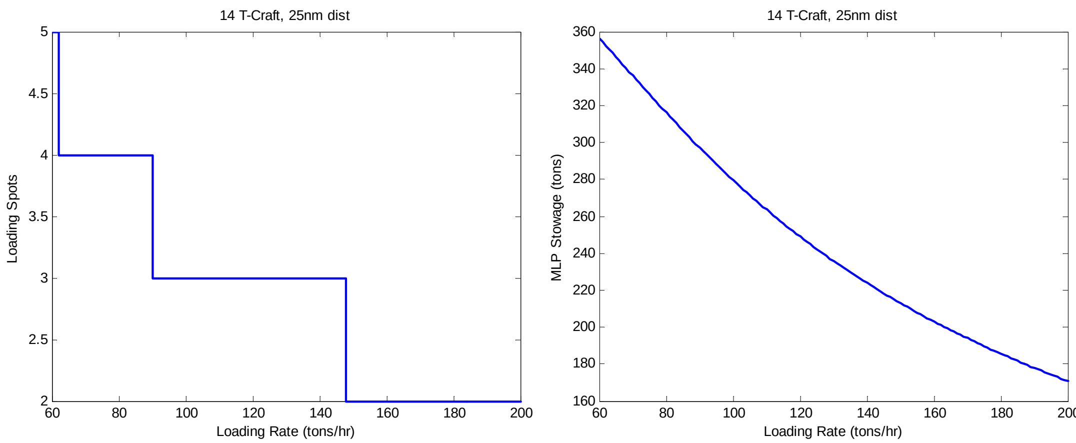

Figure 57. Case #122 / 14 T-Craft / 25 nm

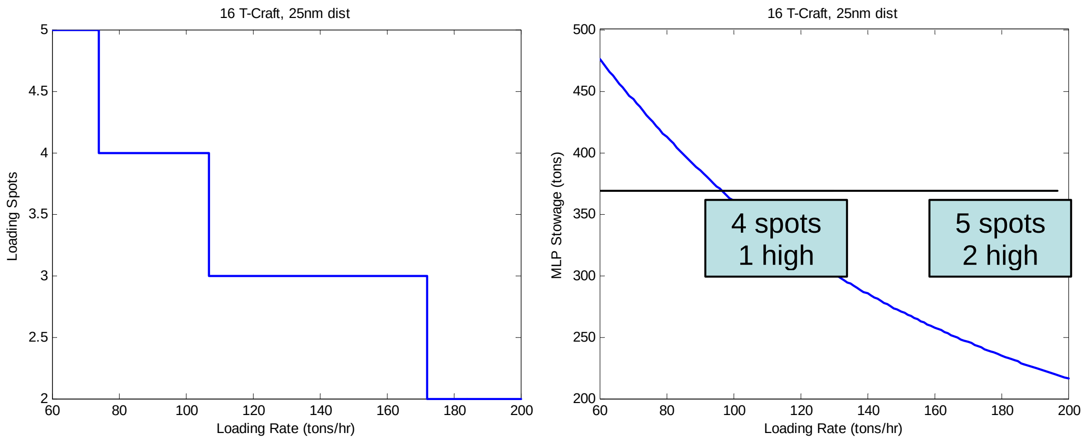

Figure 58. Case #123 / 16 T-Craft / 25 nm

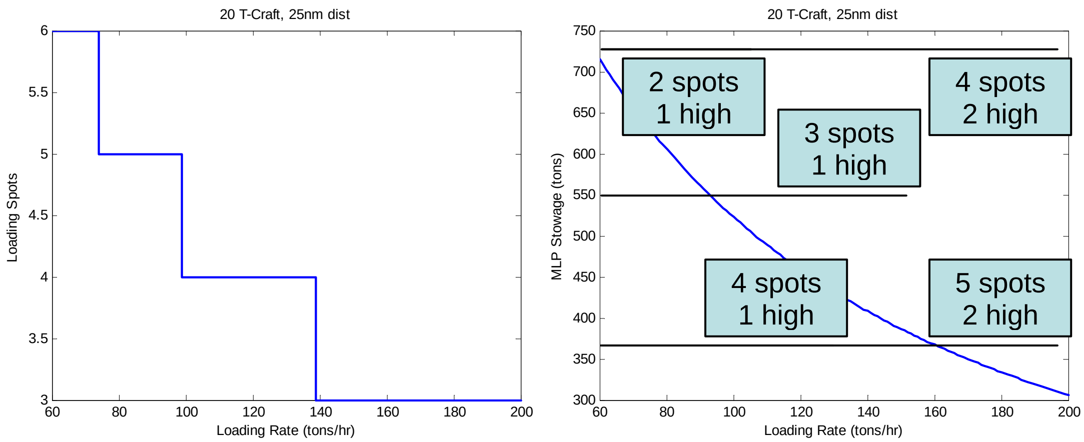

Figure 59. Case #125 / 20 T-Craft / 25 nm

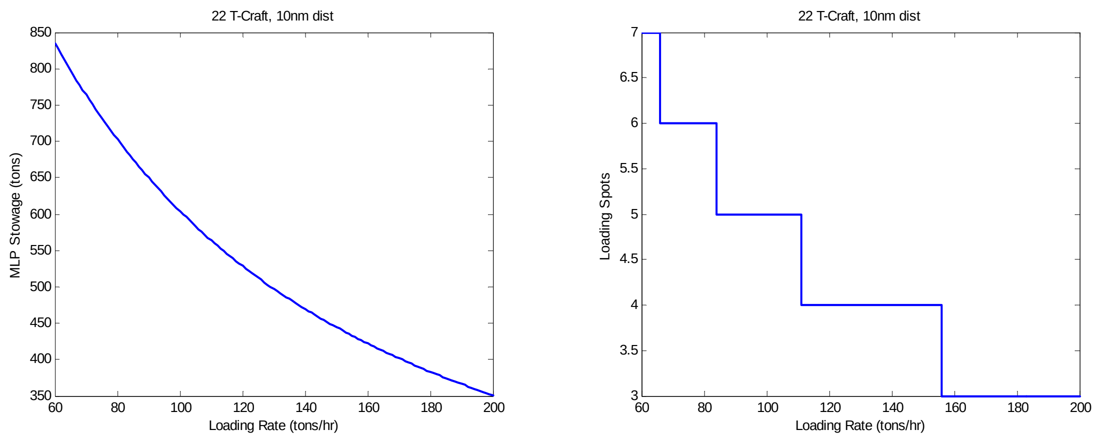

Figure 60. Case #126 / 22 T-Craft / 25 nm

C. SUMMARY

The results of the MLP modeling are shown in Table 18 and 19. As expected, these results demonstrate that with an increase in load rate more connectors can be loaded without having to wait for an open loading spot. Also, with an increase of distance, more connectors are required to keep the loading spots at 100% capacity. By varying the type of connector, the only thing that changes besides the size of the loading spots is the amount of payload each can carry. Therefore less T-Craft and LCAC(X)s can be used since it takes more time to fully load and they take more space on the MLP.

		Standard Deck Space			
Connector	Distance	100% Load Rate	133% Load Rate	166% Load Rate	200% Load Rate
LCAC	10nm	7/34	7/42	7/48	7/54
LCAC	25nm	7/40	7/48	7/56	7/64
LCAC(X)	10nm	5/16	5/20	5/22	5/24
LCAC(X)	25nm	5/18	5/22	5/24	4/26
T-Craft	10nm	4/12	4/14	3/14	3/16
T-Craft	25nm	4/12	4/14	4/16	3/16

Table 18. Ideal MLP Loading Spots/Number of Connectors (Standard Deck Space)

		Deck Space X 2			
Connector	Distance	100% Load Rate	133% Load Rate	166% Load Rate	200% Load Rate
LCAC	10nm	8/40	8/48	8/56	8/64
LCAC	25nm	8/46	8/54	8/64	8/74
LCAC(X)	10nm	6/20	6/22	6/28	6/30
LCAC(X)	25nm	6/22	6/26	6/30	5/34
T-Craft	10nm	4/12	4/14	4/18	4/20
T-Craft	25nm	5/14	4/16	4/20	4/22

Table 19. Ideal MLP Loading Spots/Number of Connectors (Deck Space X2)

The final step in this study is to see how each case stands up in terms of the overall logistical goal of maximizing throughput.

VII. THROUGHPUT SIMULATION

A. OVERVIEW

To evaluate the throughput in each of the cases mentioned in Chapter VI, a Fleet Sustainment simulation developed by Professor Joshua Gordis, Naval Postgraduate School, is used for this study. The simulation uses MATLAB and a "time domain simulation code in order to allow 'real time' prediction of throughput rates and optimization of sustainment network topology" [23]. While still in development it already provides an invaluable tool to discover trends in different scenarios.

B. RESULTS

In this simulation, we have 4,480 tons being transferred from a container ship to the objective. This amount represents the amount of cargo required to supply four Marine Corps Expeditionary Battalions (MEB) or one regiment for one week [5]. One of the most unexpected results in this study comes in Figure 61 and 62 where it is apparent that throughput actually decreases with an increase in connector payload. As discussed in Chapter VI, with larger payload there is a decrease in the number of connectors that are able to be used. Current practice relies on the belief that it is better to have a large cargo carrier than many smaller ones. This may not be the case here since the available space to load on the MLP is so limited. In Table 20 and Figure 61 it is shown that for standard deck space on the MLP when using the LCAC, there are clear increases in the throughput rate when the load rate is increased to 133% or an increase to 80 tons/hr. These increases then start to level off with further increases of load rate. With LCAC(X) and T-Craft, increases are observable to 166% load rate or 100 tons/hr and then start to level off. This holds true for both 10 and 25 nm distances to the objective.

		Standard Deck Space			
Connector	Distance	100% Load Rate	133% Load Rate	166% Load Rate	200% Load Rate
LCAC	10nm	353.1	448.0	429.2	431.8
LCAC	25nm	333.4	416.7	402.1	399.9
LCAC(X)	10nm	228.6	282.5	328.4	353.5
LCAC(X)	25nm	220.2	269.7	309.0	314.4
T-Craft	10nm	191.9	229.4	217.5	246.3
T-Craft	25nm	185.9	213.0	257.1	236.6

Table 20. Throughput Rate (tons/hr) Standard Deck Space

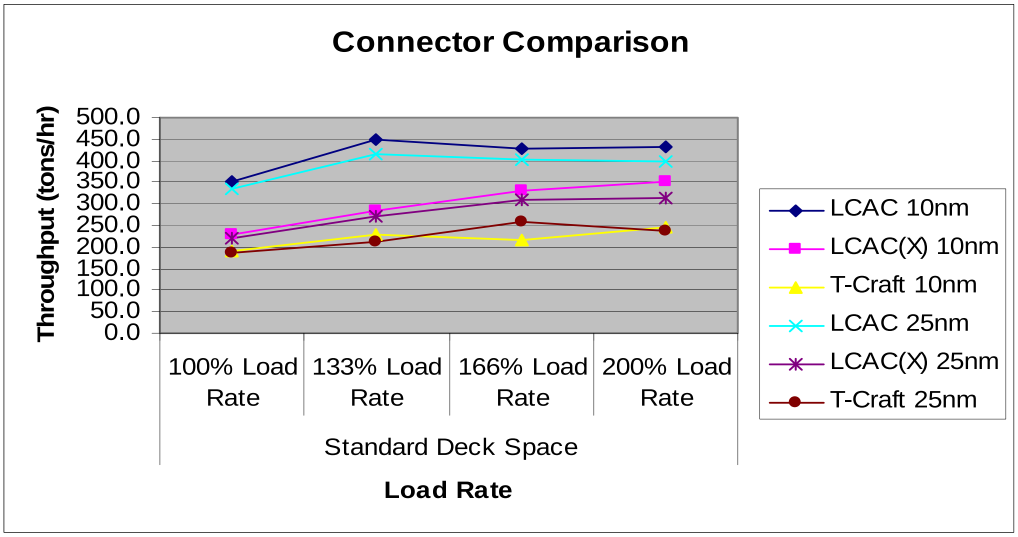

Figure 61. Throughput Rate (tons/hr) Standard Deck Space

By doubling the deck space as shown in Table 21 and Figure 62 similar results are seen for the increase of throughput as a function of connector load rate.

		Deck Space X 2			
Connector	Distance	100% Load Rate	133% Load Rate	166% Load Rate	200% Load Rate
LCAC	10nm	389.6	431.8	432.5	430.5
LCAC	25nm	365.7	404.4	399.9	403.3
LCAC(X)	10nm	261.4	317.2	355.3	360.7
LCAC(X)	25nm	250.4	303.1	338.1	333.8
T-Craft	10nm	191.9	229.4	272.0	303.7
T-Craft	25nm	216.2	226.3	260.2	289.0

Table 21. Throughput Rate (tons/hr) Deck Space X 2

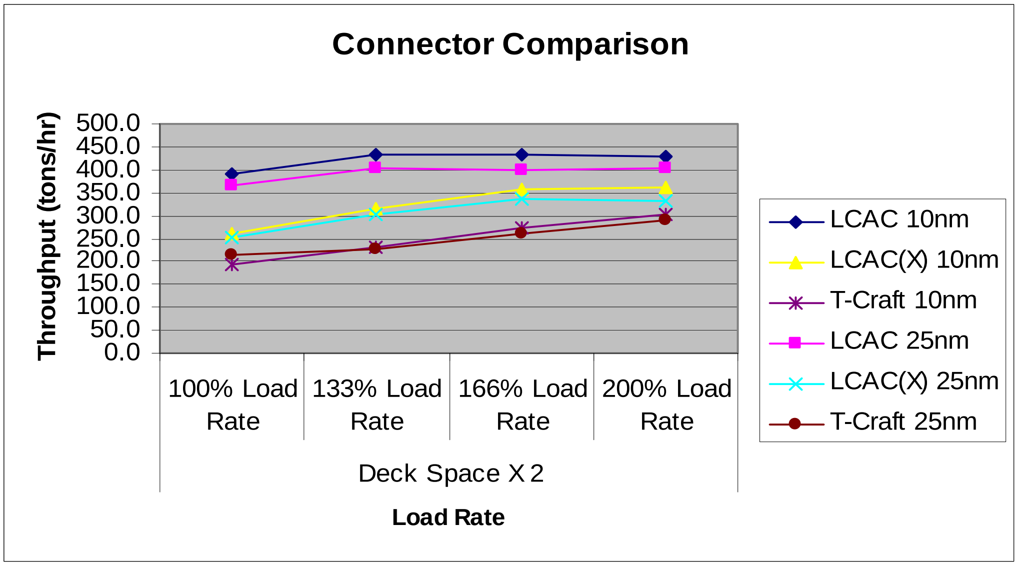

Figure 62. Throughput Rate (tons/hr) Deck Space X 2

To observe increase in throughput as a function of MLP deck space it is observed for LCACs in Figure 63, that there is an advantage to having more stowage on the MLP when the connector load rate is 100% at 60 tons/hr but that advantage is lost when the load rate is increased.

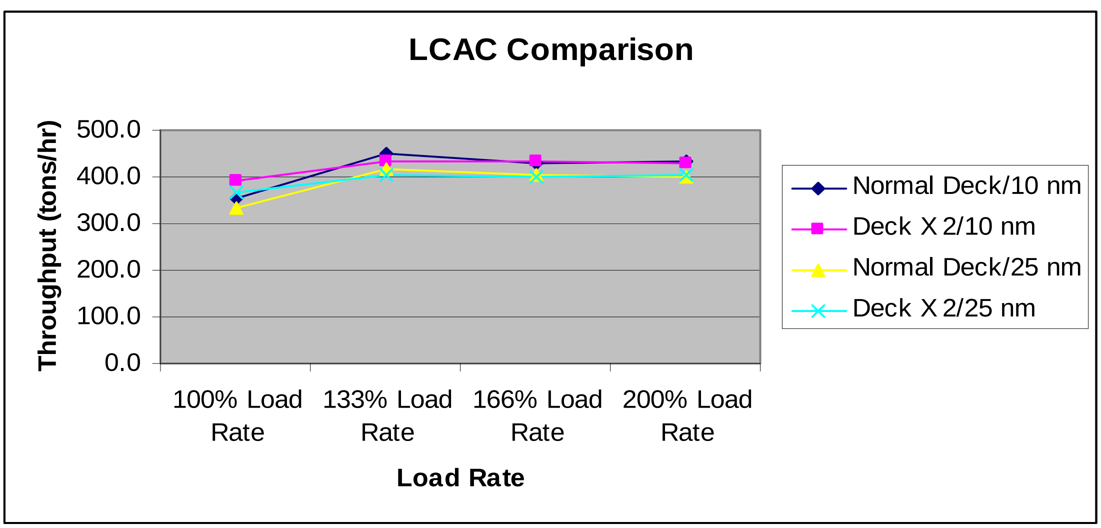

Figure 63. MLP Deck Space Comparison (LCAC)

When observing the LCAC(X) in Figure 64, the same advantage is extended to 166% load rate (100 tons/hr) for the 10 nm distance to the objective and all the way to 200% load rate (120 tons/hr) for the 25 nm distance to the objective.

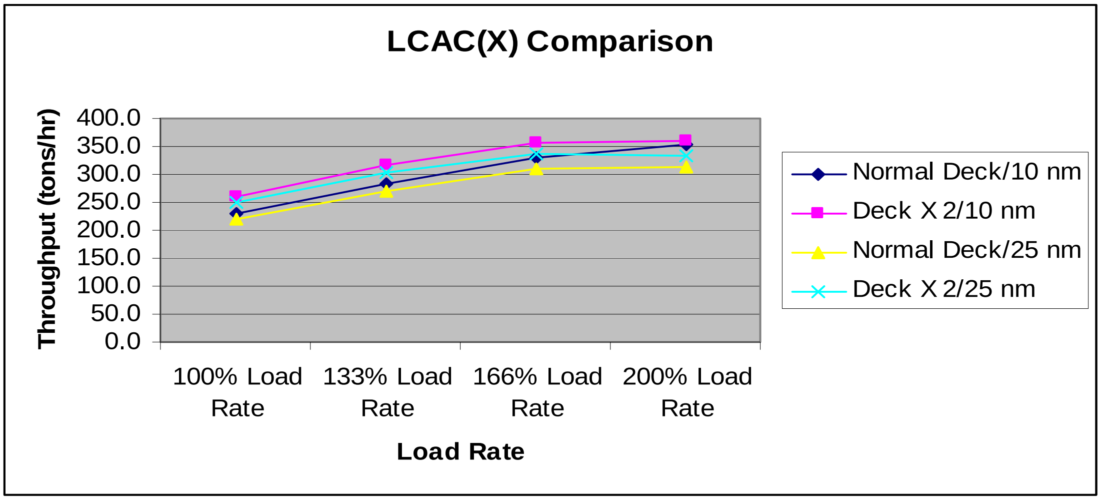

Figure 64. MLP Deck Space Comparison (LCAC(X))

For the T-Craft advantages of increasing the deck space are not evident until the load rate is increased to 166% (100 tons/hr) and 200% (120 tons/hr) as seen in Figure 65.

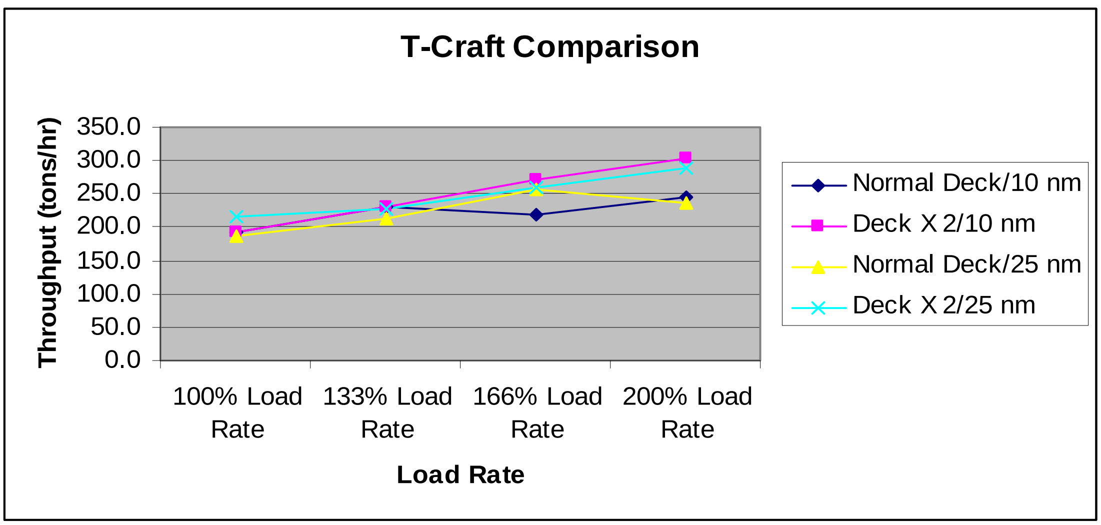

Figure 65. MLP Deck Space Comparison (T-Craft)

Percent increases in throughput is tabulated below in Tables 22 and 23 and shown in Figure 66 for each of the connectors. Values represent increase over that connector with increasing load rate and available MLP deck space.

		Standard Deck Space			
Connector	Distance	100% Load Rate	133% Load Rate	166% Load Rate	200% Load Rate
LCAC	10nm	0.00%	26.88%	21.55%	22.29%
LCAC	25nm	0.00%	24.99%	20.61%	19.95%
LCAC(X)	10nm	0.00%	23.58%	43.66%	54.64%
LCAC(X)	25nm	0.00%	22.48%	40.33%	42.78%
T-Craft	10nm	0.00%	19.54%	13.34%	28.35%
T-Craft	25nm	0.00%	14.58%	38.30%	27.27%

Table 22. Percent Increase Throughput Rate Standard Deck Space

		Deck Space X 2			
Connector	Distance	100% Load Rate	133% Load Rate	166% Load Rate	200% Load Rate
LCAC	10nm	10.34%	22.29%	22.49%	21.92%
LCAC	25nm	9.69%	21.30%	19.95%	20.97%
LCAC(X)	10nm	14.35%	38.76%	55.42%	57.79%
LCAC(X)	25nm	13.71%	37.65%	53.54%	51.59%
T-Craft	10nm	0.00%	19.54%	41.74%	58.26%
T-Craft	25nm	16.30%	21.73%	39.97%	55.46%

Table 23. Percent Increase Throughput Rate Deck Space X 2

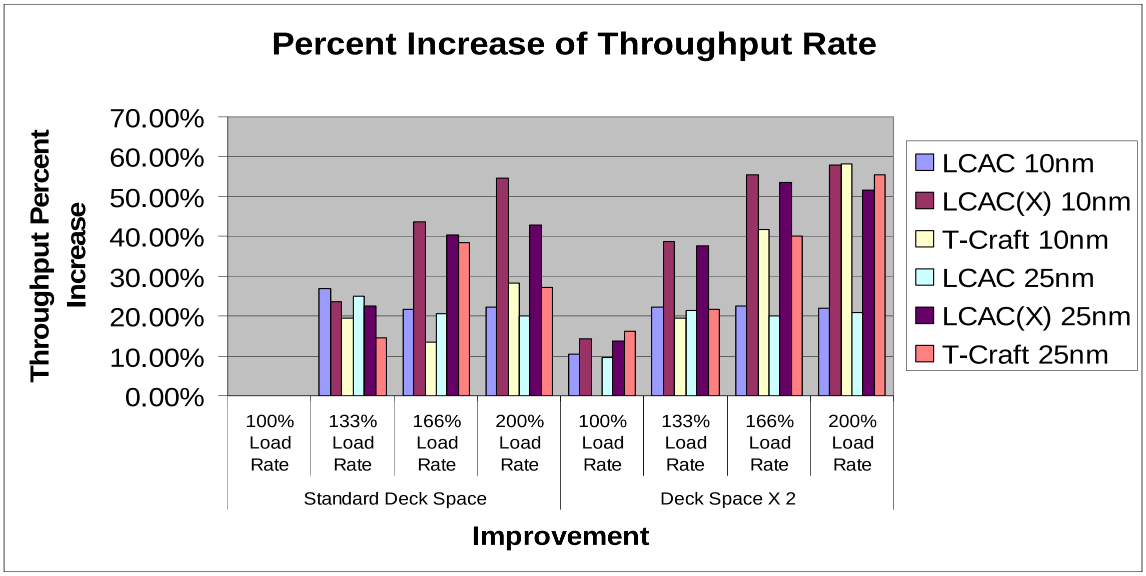

Figure 66. Percent Increase of Throughput Rate

C. SUMMARY

This study indicates that the best use of the Mobile Landing Platform (MLP) would be to employ the current LCACs in large numbers with a modest investment made to increase the load rate to about 80 tons/hr. Should other connectors be used then investments could be made to increase the available deck space on the MLP by double stacking the pallets. When using other connectors, investments could also be made to even further increase the load rate. The amount and type of connectors used in on the MLP has huge implications in the overall throughput of cargo from the Sea Base to U.S. forces ashore. Therefore, it is vital that we analyze this facet of the logistical train and design it to meet our present and future requirements.

VII. DISCUSSION

Perhaps the biggest surprise in this study was the apparent advantage gained by using an increased number of Landing Craft Air Cushioned (LCAC) over a smaller number of larger connectors such as the Next Generation Landing Craft Air Cushioned (LCAC(X)) or the Sea Base Connector Transformable Craft (T-Craft). This may be caused by the limited amount of space on the Mobile Landing Platform (MLP) which reduces the amount of loading spots the LCAC(X) and the T-Craft can utilize. The possible implications of this result certainly indicate that more study is required. One advantage of the T-Craft that was not able to be considered in this study was the ability of these vessels to self deploy. This single ability may overshadow everything else due to the complications that may arise in getting 50 or so LCACs into theater. Other advantages may be gained in utilizing the T-Craft in an initial assault phase of the operation with their ability to carry multiple vehicles ashore. These advantages may or may not outweigh the current generation LCAC's advantage in logistical throughput.

The elimination of the T-AKE now represents new challenges in the logistical train. Previously it was assumed that this platform would act as the warehouse for the Sea Base. Now, with containers being directly transferred to the MLP, this platform must now receive the containers and then sort and store the cargo on limited deck space in such a manner that selective delivery is possible. This may be done with an Automated Warehouse (AW) type technology and is certainly an area for further research.

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IX. CONCLUSION

This report looks at a key part of the Sea Base which is the Mobile Landing Platform (MLP) and makes recommendations on the initial concept design. Sea Basing is the future of expeditionary warfare and it is important to consider how to invest limited funds with the continued demand for fiscal responsibility of the United States Navy. It is imperative to conduct extensive study on the architecture of the Sea Base concept, its platforms and its technologies.

A. MOBILE LANDING PLATFORM DESIGN

The following recommendations are made for the initial concept design of the MLP.

- Using this study it is determined that the MLP should service approximately 48 of the current Landing Craft – Air Cushioned (LCAC) with a total of seven loading spots.
- Approximately 7,837 sqft should be set aside for storage on the MLP.
- Investment should be made in a technology that increases the connector load rate on the MLP to 80 tons/hr. This may be accomplished with Compact Agile Material Mover (CAMM).
- Large to Large Vessel Interface Lift On / Lift Off (LVI LO/LO) is essential to the operation and the crane should be placed on the MLP to enable transfer of ISO containers directly from the cargo ship.
- Small to Large Vessel At-Sea Transfer (STLVAST) is also essential to the operation for the transfer of cargo from the MLP to the LCACs.
- Shipboard ISO Container Breakout and Repacking (CB&R) should be invested in due to limited deck space on the MLP.
- Interface Ramp Technologies (IRT), Automated Warehouse (AW), and High Rate Vertical / Horizontal Material Movement (HRVHMM) was not used in this model with the elimination of the T-AKE from the supply train. Further research should be done to see if these technologies have any utilization on the MLP.

B. RECOMMENDATIONS FOR FURTHER STUDY

The following areas are recommended for further study.

- Air connectors were not looked at beyond the initial study in this report due to the focus on the MLP. Further studies should consider where the air connectors load and what impact the proximity will have on the simultaneous loading of other air and surface connectors.
- Further research should be done in the area of selective delivery meaning how well the MLP will be able to pick and choose what it delivers to the objective with current and future technologies such as Automated Warehouse (AW).
- Study should also be done on combinations of connectors including the Joint High Speed Vessel (JHSV) assuming a docking facility is available ashore. This needs to be done because JHSV is a major asset in theater and could be used in combination with other surface connectors.
- Further study should also be conducted on the area of cost. This includes fuel for the platforms, with attention paid to the connectors. Cost of developing new technologies and platforms should be considered as well as acquisition of these platforms.

This study uses physics based principles to model and assess the Mobile Landing Platforms (MLP) system design. With this initial design, more extensive modeling and simulation may now be conducted to refine the architecture of the Sea Base, its platforms, and its operations. It provides a foundation for a broad area of study important to maximize our nation's ability to conduct expeditionary warfare in the future and project power ashore.

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